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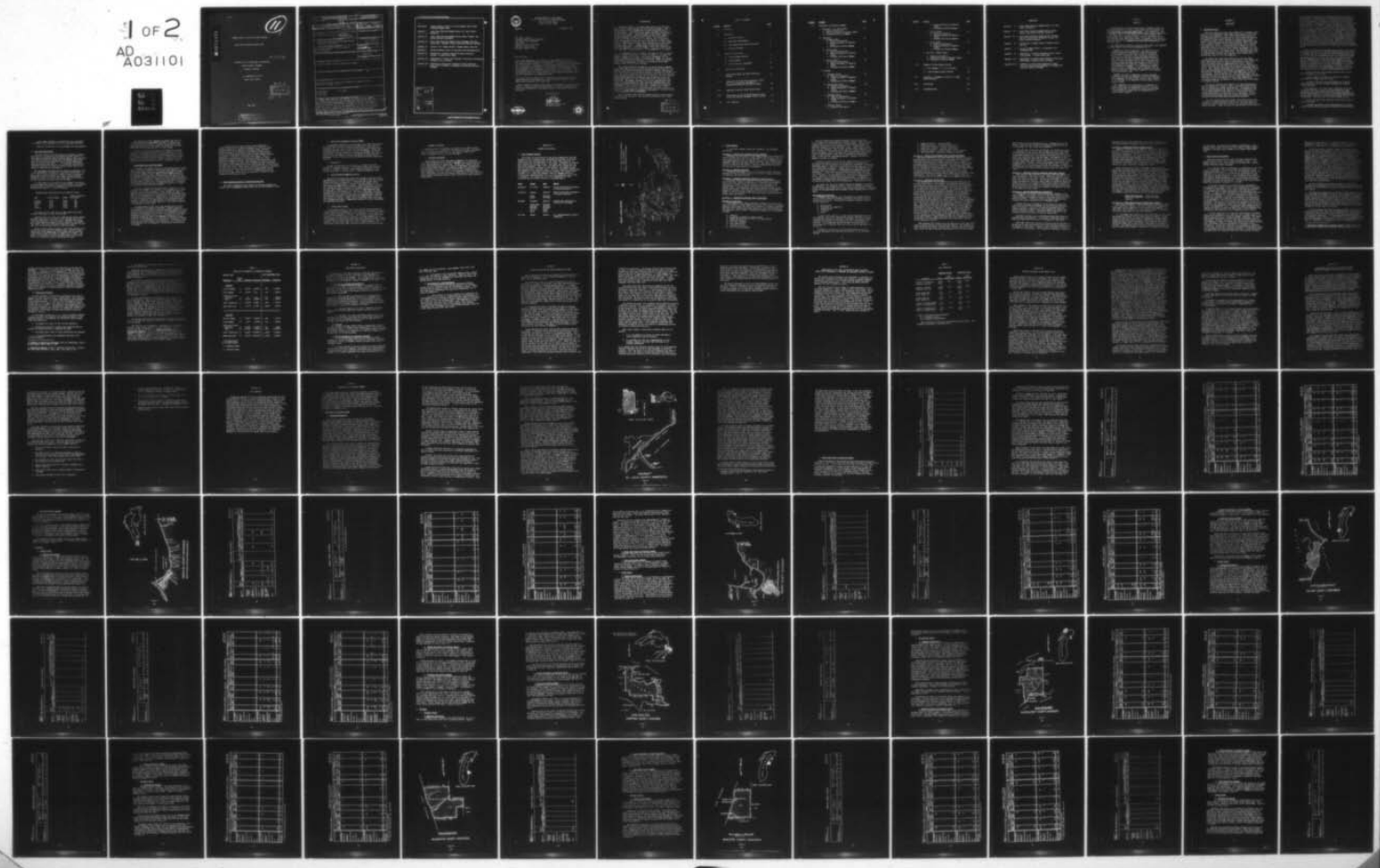

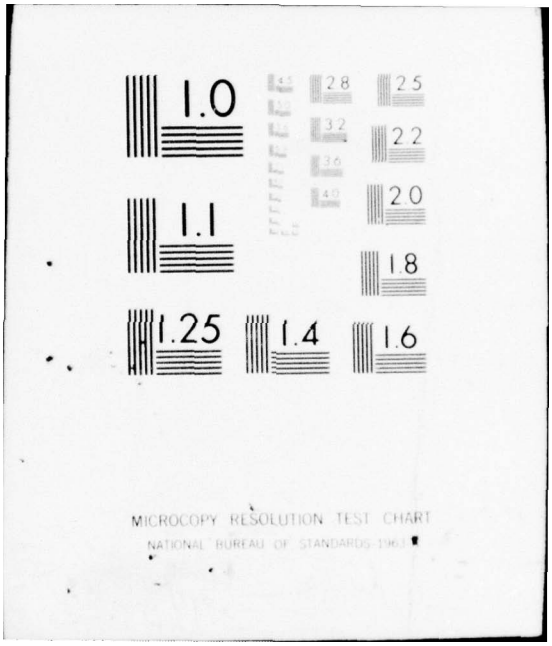
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SUMMARY REPORT OF THE PILOT STUDY PROGRAM,

GREAT LAKES SHORELAND DAMAGE STUDY

Prepared by U.S. Army Corps of Engineers,
North Central Division
Chicago, Illinois

in cooperation with the

Great Lakes States

May 1976

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This report describes the results of a pilot study of damages in 11 Great Lakes counties for the high water period 1972-1974. The program's purpose ~~of the pilot program~~ was to develop a reliable and inexpensive reconnaissance data collection method, to initiate coordination between the Corps of Engineers and responsible state and local agencies, and to gather the damage data for the 11 counties. The pilot program helped demonstrate how to streamline some of the data collection methods and pointed out ways to substitute for or eliminate other activities.

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Main Report	Summary Report of the Pilot Study Program, Great Lakes Shoreland Damage Study.
Appendix I A031 262	Great Lakes Shoreline Damage Survey; St. Louis County, Minnesota
Appendix II A031 263	Great Lakes Shoreline Damage Survey; Brown, Douglas, and Racine Counties, Wisconsin
Appendix III A031 081	Great Lakes Shoreline Damage Survey; Muskegon, Manistee, Schoolcraft, Chippewa, Alcona, and Huron Counties, Michigan
Appendix IV A031 079	Contract for a Damage Survey of Oswego County, New York
Appendix V A031 259	Shoreline Damage Survey: An Appraisal with Recommendations
Appendix VI A031 260	Engineering - Economic Analysis of Shore Protection Systems: A Benefit/Cost Model
Appendix VII A031 080	Measurement of Coastal Bluff Recession from Aerial Photographs, Muskegon County, Michigan
Appendix VIII A031 261	Comparison of Field Data Collection to Date Collected Using Study Instruments in Muskegon and Manistee Counties, Michigan

DEPARTMENT OF THE ARMY
NORTH CENTRAL DIVISION, CORPS OF ENGINEERS
536 SOUTH CLARK STREET
CHICAGO, ILLINOIS 60605

NCDPD-SS

1 September 1976

Mr. Peter L. Wise
Chairman, GLBC Standing Committee
on Coastal Zone Management
Room 1010
Marina City Office Building
300 North State Street
Chicago, Illinois 60610

Dear Mr. Wise:

This report summarizes the efforts of a partnership of four of the Great Lakes States--Michigan, Minnesota, New York, and Wisconsin--and the North Central Division, U.S. Army Corps of Engineers, in the development of a pilot study to determine shoreland damages along the Great Lakes. Eleven counties were selected for initial detailed study and the results are contained in the appendixes to this report. The concurrence of the representatives of the involved states is attached to this report. The techniques developed are being applied to the remaining shoreland counties with the expectation of completion by 1979.

This effort is in accordance with "A Strategy for Great Lakes Shoreland Damage Reduction" developed by the Federal Regional Council V--Great Lakes Basin Commission Joint Task Force.

A limited number of copies of this report and appendixes is being printed. However, a brochure giving the main points of the pilot summary will be printed and distributed to the general public, particularly shoreland residents.

Sincerely yours,

ROBERT L. MOORE
Brigadier General, USA
Division Engineer

INTRODUCTION

High water levels in the Great Lakes have in the 1972-1975 period caused widespread property and shoreland damages. Most of the flood and erosion damages have occurred during periods of storm activity. Conditions during storms increased the effects of the high water levels. Winds push against the surface waters of a lake, artificially tilting the lake's surface which causes a further temporary increase in water levels. This condition is called the "storm water level." In addition, the storm-driven winds increase wave height and force; this effect is called "wave run-up." Together storm water levels and wave run-up cause higher shoreline water levels. Damages from flooding and erosion are increased many times. Flooding damages result from inundation or wave force against the affected property. Erosion is the cutting or eating away of shoreland due to the scouring effects of waves.

The increased severity of damage indicates the need to reevaluate the economic feasibility of means to prevent or mitigate the harmful effects of high water. An accurate measurement of the amount of damage is necessary to determine and compare the economic justification of various alternative solutions. Some alternatives, which envision regulating the levels of the entire Great Lakes System, could cost billions of dollars.

This report describes the results of a pilot study of damages in 11 Great Lakes counties for the high water period 1972-1974. The purpose of the pilot program was to develop a reliable and inexpensive reconnaissance data collection method, to initiate coordination between the Corps of Engineers and responsible state and local agencies, and to gather the damage data for the 11 counties. The pilot program helped demonstrate how to streamline some of the data collection methods and pointed out ways to substitute for or eliminate other activities. The damage estimates of the pilot program apply only to the 11 counties surveyed. They cannot be extrapolated to the remaining counties along the Great Lakes shoreline with sufficient reliability. The diversity of geologic, climatic, and economic characteristics of the Great Lakes shoreland precludes using data in one county or for dissimilar reaches of shoreline to represent another county or another reach of shoreline.

Thus, the Great Lakes Shoreland Damage Survey is being expanded to cover all 83 counties of the United States portion of the Great Lakes shoreline.

TABLE OF CONTENTS

SECTION	SUBJECT	PAGE
I.	Authority	1
II.	Background	
	A. Purpose and Scope	2
	B. Lake Level Fluctuations	3
	C. Study Organization and Participants	4
	D. Relevant Programs	5
III.	Conduct of the Study	
	A. Pilot Program Counties	8
	B. Study Program	9
	C. Data Collection Procedures	14
IV.	Statistical Evaluation	19
V.	Benefit/Cost Model for Shore Protection Systems	21
VI.	Comparison of Field Data Collection to Data Collected Using Study Instruments in Muskegon and Manistee Counties, Michigan	24
VII.	Sampling Procedure (Huron County Study)	26
VIII.	Measurement of Coastal Bluff Recession from Aerial Photographs, Muskegon County, Michigan	29
IX.	Soil Sampling	32

SECTION	SUBJECT	PAGE
X.	Evaluation of Shoreland Damages	
	A. Minnesota - St. Louis County	33
	1. Physical Description	
	2. Nature and Extent of Physical Losses	
	3. Flooding and Erosion Damages	
	B. Wisconsin	
	1. Douglas County	37
	a. Physical Description	
	b. Nature and Extent of Physical Losses	
	c. Flooding and Erosion Damages	
	2. Brown County	40
	a. Physical Description	
	b. Nature and Extent of Physical Losses	
	c. Flooding and Erosion Damages	
	3. Racine County	46
	a. Physical Description	
	b. Nature and Extent of Physical Losses	
	c. Flooding and Erosion Damages	
	C. Michigan	
	1. Chippewa County	50
	a. Physical Description	
	b. Nature and Extent of Physical Losses	
	c. Flooding and Erosion Damages	
	2. Schoolcraft County	58
	a. Physical Description	
	b. Nature and Extent of Physical Losses	
	c. Flooding and Erosion Damages	
	3. Muskegon County	63
	a. Physical Description	
	b. Nature and Extent of Physical Losses	
	c. Flooding and Erosion Damages	
	4. Manistee County	67
	a. Physical Description	

SECTION	SUBJECT	PAGE
	b. Nature and Extent of Physical Losses	
	c. Flooding and Erosion Damages	
	5. Alcona County	72
	a. Physical Description	
	b. Nature and Extent of Physical Losses	
	c. Flooding and Erosion Damages	
	6. Huron County	76
	a. Physical Description	
	b. Nature and Extent of Physical Losses	
	c. Flooding and Erosion Damages	
	D. New York - Oswego County	81
	1. Physical Description	
	2. Nature and Extent of Physical Losses	
	3. Flooding and Erosion Damages	
XI.	Summary of Pilot Program Results	
	A. Total Damages in 11 Pilot Counties	91
	B. Study Methods--Lessons Learned	91
XII.	Estimation of Damages for Total U.S. Great Lakes Shoreland	101
XIII.	Conclusions	103
XIV.	Recommendations	104

APPENDICES

Appendix I - Great Lakes Shoreline Damage Survey; St. Louis County, Minnesota

Appendix II - Great Lakes Shoreline Damage Survey; Brown, Douglas, and Racine Counties, Wisconsin

Appendix III - Great Lakes Shoreline Damage Survey; Muskegon, Manistee, Schoolcraft, Chippewa, Alcona, and Huron Counties, Michigan

Appendix IV - Contract for a Damage Survey of Oswego County, New York

Appendix V - Shoreline Damage Survey: An Appraisal with Recommendations

Appendix VI - Engineering - Economic Analyses of Shore Protection Systems: A Benefit/Cost Model

Appendix VII - Measurement of Coastal Bluff Recession from Aerial Photographs, Muskegon County, Michigan

Appendix VIII - Comparison of Field Data Collection to Data Collected Using Study Instruments in Muskegon and Manistee Counties, Michigan

SECTION I

AUTHORITY

The Great Lakes Shoreland Damage Study is conducted under the continuing authority of a 1952 Congressional Resolution granted for the Water Levels of the Great Lakes Study. This authorization was a response to the high water period and shoreland damages experienced in the early 1950's. It was redirected in 1965 to support the International Joint Commission study which was carried out by the International Great Lakes Levels Board. The Board's final report on the study was entitled Regulation of Great Lakes Water Levels, dated December, 1973.

The authorizing resolution, adopted 26 June 1952 by the Committee of Public Works of the House of Representatives is:

> "WHEREAS, the Chief of Engineers has completed a preliminary examination pursuant to a resolution adopted by the Committee on Public Works, House of Representatives, U.S., on March 26, 1952, requesting a review of 'the report of the Chief of Engineers dated November 9, 1920, and other pertinent reports relating to the water levels of the Great Lakes, with a view to determine the property damage resulting from changes in levels of the Great Lakes and the feasibility of measures to prevent the recurrence of damages. In conducting this investigation the Chief of Engineers shall coordinate with the affected States and other Federal agencies to the maximum extent practicable'; and
>
> "WHEREAS, the Chief of Engineers, after a favorable finding of The Board of Engineers for Rivers and Harbors, has recommended by letter, dated June 24, 1952, directed to the Chairman of the Committee on Public Works, that a survey be made;
>
> "NOW, THEREFORE, Be it resolved by the Committee on Public Works, House of Representatives, U.S., that the Board of Engineers for Rivers and Harbors be and hereby is, authorized to proceed with the preparation of a survey report thereon."

SECTION II

BACKGROUND

A. Purpose and Scope

Lake level regulation plans were evaluated in a December, 1973, report by the International Great Lakes Levels Board to the International Joint Commission. This report found that regulation of Lakes Michigan-Huron by construction of control works and dredging of channels at their outlet combined with regulation of Lakes Superior and Ontario, would not provide benefits commensurate with costs. Several alternative plans were developed, and a trial plan was evaluated in detail. This representative plan would require regulatory works in the St. Clair and Detroit Rivers at a cost of about $150 million and Detroit River channel enlargement at a cost of about $50 million. The annual costs, including additional costs for Lake Superior, would be $18 million. The estimated upper limit of benefits from this plan was $3 million, which would yield a benefit/cost ratio of 0.17 (Plan SMHO-11).

The report also found that regulation of all five lakes, employing existing control works for Lakes Superior and Ontario and newly constructed works for Lakes Michigan-Huron and Lake Erie, would not provide benefits commensurate with costs. Several alternative plans were developed and a trial plan was evaluated in detail. This representative plan would require regulatory works in the St. Clair, Detroit and Niagara Rivers at a cost of $266 million and Detroit and Niagara Rivers channel enlargements at a cost of $105 million. The annual costs, including additional costs for Lake Superior, would be $28 million. The estimated upper limit of benefits from this plan was $15 million, which would yield a benefit/cost ratio of 0.54 (if benefits of "trial plan" SMHEO-38 are projected in some way as benefits of other plans which were brought to "refined" status).

The report concluded that regulation of Lakes Michigan-Huron by the construction of works in the St. Clair and Detroit Rivers does not warrant any further consideration. To regulate the outflow of Lakes Michigan-Huron and at the same time maintain close to the natural profile of the 89-mile St. Clair-Detroit River system would require at least nine control structures. The cost of constructing this many works far exceeds any benefits to be expected from regulating Lakes Michigan-Huron outflows.

The 1973 International Great Lakes Levels Board report also evaluated a proposed Regulation Plan SO-901, which involves modification of the St. Marys River control works for more effective winter operation. Under this plan the same minimum outflow specified

by the approved regulation plan (1955 Modified Rule of 1949) would be maintained. Minimum levels on Lake Superior and mean levels on all lakes would be raised slightly. High levels on Lake Erie would occur less frequently. Extreme levels would tend to be moderated on Lakes Superior, Michigan, and Huron. Annual benefits of Plan SO-901 were estimated to be $927,000 to commercial navigation, $640,000 to power production, and erosion reduction benefits totalling $720,000 on the U.S. shore. Annual erosion losses on Lake Superior, however, would be increased by $109,000. Overall the plan provided an estimated $2.37 million benefits for an annual cost of $70,000. By letter dated 29 June 1973, the IJC directed the International Lake Superior Board of Control, starting 1 July 1973, to continue providing emergency relief to the downstream lakes by using Plan SO-901 as a guide in regulating Lake Superior. This was to be done for as long as the levels on the downstream lakes remained critically high. Since that time, the IJC and its International Lake Superior Board of Control have continued the emergency action in regulating Lake Superior, while not exceeding the Lake Superior monthly mean level of 602.0 feet, the upper regulation limit.

There is concern among shoreland property owners and the states which border the Great Lakes that the estimates of Great Lakes shoreland damages used in the International Joint Commission study based on 1951-1952 data do not adequately reflect the increased shoreland development which has occurred since 1952. The costs of potential remedial measures could not then be evaluated against the true measure of their benefits. The people of the Great Lakes States, through their representatives on the Federal Regional Council/Great Lakes Basin Commission Joint Task Force on Reduction of Shoreland Damages, requested the Corps of Engineers to conduct a study to determine the extent of increased damages due to high lake levels. The objectives of the Great Lakes Shoreland Damage Study are to:

- Develop flood and erosion damage estimates using a study method acceptable to the States.

- Provide a base of information to evaluate the economic justification of damage reduction options.

- Institute a working relationship between the States and Federal agencies to aid the eventual implementation of damage reduction measures.

Upon completion of the total study a comparison can be made of benefits and costs of various lake level regulation plans presented in the International Great Lakes Levels Board report. A pilot program involving the collection of shoreland damages due to erosion and flooding in 11 selected counties around the Great Lakes was developed. The objectives of the pilot program were to:

- Fulfill the above three objectives of the study for the 11 selected counties.

- Determine the extent to which data collected in the pilot program counties could be projected to other Great Lakes counties.

• Refine damage assessment procedures for later application if necessary to the remainder of the U.S. Great Lakes shoreline.

• Establish coordination with other Federal and State agencies.

B. Lake Level Fluctuations

The water levels of the Great Lakes are constantly changing. There are four categories of fluctuations of water levels: (1) short period fluctuations caused by meteorological events which can last from a few hours to several days; (2) seasonal fluctuations which reflect the annual hydrologic cycle from the summer high level to the winter low level; (3) long-range fluctuations requiring several years time; and (4) fluctuations resulting from artificial regulation of levels by existing control works at the outlets of Lakes Superior and Ontario.

The long-range fluctuations are the results of persistent high or low precipitation occurring over a period of several years. In other words, if we have a period of years for which precipitation falling on the basin is heavier than normal, the basin becomes "saturated." Then, after that, even normal precipitation amounts can cause greater than normal runoff to the lakes.

The Great Lakes basin precipitation has averaged five percent to seven percent above normal over the last 11 years. The following tabulation shows a lake by lake breakdown of the average annual precipitation values for the 1965-1975 period.

Average Annual Precipitation for the 1965-1975 Period

Lake	11-Year Average	Normal	Percent Deviation from Normal
Superior	33.36	29.63	+13%
Michigan	33.34	31.30	+7%
Huron	33.24	31.31	+6%
Erie	35.50	33.84	+5%
Ontario	35.97	34.33	+5%

The result has been that record or near record high levels occurred on the lakes in 1972, 1973 and 1974.

Because of the size of the Great Lakes and the limited natural discharge capacities of the outflow rivers, extreme high or low levels and flows persist for considerable time after the factors which caused them have changed or ceased. Therefore, the present high levels on the upper lakes can be expected to continue for some time, even if precipitation should be less than normal.

There is much evidence to support a correlation between yearly average lake levels and bluff-recession rates. However, higher water levels in the summer than in the winter does not mean that bluff-recession rates are greater in summer than in winter. The weight of the evidence is to the contrary--greater bluff erosion during the stormy winter season than during the summer.

The distinction between seasonal and annual lake levels is important because shoreland damages are used to formulate and justify lake regulation plans. A regulation plan which lowers summertime peak levels at the expense of raising fall and winter levels would do more harm than good to erosion areas.

There is a further need to qualify the degree of potential damage and bluff-recession rates due to the incidence of storms during all seasons and there are no present facts as to the long-term effects of seasonal fluctuations and storm incidence and the cumulative effects of various stages on erosion and recession. However, such investigations are outside the scope of the study authorization given by Congress, which is reproduced on page 1.

C. Study Organization and Participants

In August, 1973, member agencies of the Federal Regional Council (FRC), the Corps of Engineers, Great Lakes Basin Commission (GLBC), and the Great Lakes States, acting together, prepared a program entitled "A Strategy for Great Lakes Shoreland Damage Reduction." The strategy identified basic planning ground rules and specified the information and data needed to assess plans for possible implementation. It categorized necessary actions as Planning, Engineering, and Land Control activities. Planning activities were divided into Initial Planning, Early Action, and Sustained Action. A comprehensive Shoreland Damage Study was recommended as part of the "early action" group of the Planning Activities.

The Corps of Engineers developed a plan to carry out a pilot study for this program. The keystone of the approach to this study was that it was to be a cooperative effort between the Corps of Engineers and the involved states. To assure that the damage estimates to be developed would be acceptable to all parties, the states would be fully involved in the study process. It was decided that the states' approval would be obtained for any study methodology to be used. If possible, the administration of the studies would be contracted by the Corps to state agencies or other public organizations designated by the states.

The participants of the pilot study program are as follows: (1) in Minnesota, the Minnesota Department of Natural Resources subcontracted to the Arrowhead Regional Development Commission, which actually collected the data; (2) the Wisconsin Department of Natural Resources subcontracted to the University of Wisconsin at Milwaukee, Department of Geological Sciences; (3) in Michigan, the study was conducted through the Coastal Zone Management Laboratory of the University of Michigan; and (4) in New York the study was performed by the St. Lawrence-Eastern Ontario Commission. In addition, survey forms and statistical research were developed by the Institute for Social Research and the Department of Statistics at the University of Michigan.

It should be noted that the pilot study program has yielded valuable data on damage estimates but the pilot study program limitations in regard to available funds, technical inputs and lack of an adequate state-federal working team to actually implement the program has reduced the effectiveness of the data in providing substantially reliable damage estimates especially in relation to beach and bluff losses. (This is especially true since much of the data are based on a self-administered damage assessment which had obvious shortcoming. See Section III Conduct of Study.) The problems in obtaining reliable data based on high water marks due to funding and time constraints resulted in use of estimated 100 year flood elevations in identifying the lake flood plain. Consequently, there was no technical evaluation of the effects of wave height and run-up acting against a given shoreland profile. The results will not accurately portray the effects from these forces except as perceived by property owners through the self-survey process.

D. Other Programs Relevant to Shoreland Protection

The Corps of Engineers has a number of on-going programs and studies which relate to shoreland protection on a site-specific basis.

1. Flood Plain Management Services (FPMS)

This program authorized by Section 206 of the 1960 Flood Control Act (PL 86-645), provides technical information to local units of government for their use in promoting wise use of flood plain areas consistent with the risk of flood and erosion damages. Flood plain Information Reports are prepared to define and document the flood hazard areas. Special Flood Hazard Information Studies also are conducted to provide similar technical assistance to local units of government, but are furnished without extensive technical supporting material.

2. Section 111

As part of the Rivers and Harbors Act of 1968 (PL 90-483), Section 111 provides authority to investigate, study, and construct projects to prevent or mitigate shore damage attributable to the effects on current or lake processes of Federal navigation works.

3. Erosion Control Demonstration Act

Section 54 of Public Law 93-251, the "Shoreline Erosion Control Demonstration Act of 1974" directed the Secretary of the Army, acting through the Chief of Engineers, to "establish and conduct for a period of five fiscal years a national shoreline erosion control development and demonstration program." Subsection 54(d)(1) of this Act directed the Chief of Engineers to appoint a Shoreline Erosion Advisory Panel (SEAP) to "advise the Chief of Engineers generally in carrying out provisions of this section." This Panel has been appointed and is now functioning. The Chief of Engineers requested the Panel develop a plan for searching out potential shore locations which might be suitable as "development and demonstration sites" as provided for in the Act. From a list of potential sites, the Panel will recommend the sites it deems most suitable for use as development and demonstration sites.

4. Urban Study Program

This program relates to urban areas specifically authorized in a Water Resources Development Act or by specific resolution of Congressional Public Works and Transportation Committees. It is defined in Vol. 40 Federal Register, p. 51146. The objective of the Urban Study Program is to use the Corps of Engineers' planning capabilities to help metropolitan areas solve urban water and related problems. Plans for shoreland protection measures may be developed under an urban study program. At the present time there are no urban studies in the Great Lakes Region under which shoreland protection is being studied.

5. Section 10 Permits

Under Section 10 of the River and Harbor Act of 1899 (30 Stat. 1151, 33 U.S.C. 403), permits for construction activity in navigable waters, including dredging and filling, must be issued by the Corps of Engineers before such work can begin.

6. Operation Foresight

Under Public Law 84-99, the Corps of Engineers is authorized to provide assistance in the form of emergency flood preparation and flood fighting and rescue operations. On the Great Lakes, starting in 1973 and completed in 1974, a total of 53 emergency flood protection contracts were awarded, and technical assistance and materials were provided at 86 locations where the work was accomplished by local interests. The total cost of this program was $25.8 million. This program also produced the brochure "Help Yourself" which described means by which shoreland property owners could protect their shoreline from erosion.

SECTION III

CONDUCT OF THE STUDY

A. Pilot Program Counties

The eleven counties studied in the pilot program were selected because the set of counties had characteristics thought to be representative of the remaining areas of the Great Lakes shoreline of those states able to participate in the study. Originally 15 counties were selected for the pilot study. The number was reduced when the funds were exhausted. This led to the omission of coverage on Lake Erie and the reduced coverage of Lake Ontario. The damage surveys were conducted on a statewide basis, since the contracted organizations were agencies of the state governments involved. The intense local interest in the study also suggested that the damages should be collected and organized along state political boundaries rather than by watershed. The counties and agencies responsible for data collection are as follows (see map on following page):

State	County	Lake	Agency
Minnesota	St. Louis	Superior	State of Minnesota Department of Natural Resources
Wisconsin	Douglas	Superior	State of Wisconsin Department of Natural Resources
	Brown	Michigan	
	Racine	Michigan	
Michigan	Chippewa	Superior	Coastal Zone Laboratory of University of Michigan
	Schoolcraft	Michigan	
	Muskegon	Michigan	
	Manistee	Michigan	
	Alcona	Huron	
	Huron	Huron	
New York	Oswego	Ontario	St. Lawrence-Eastern Ontario Commission

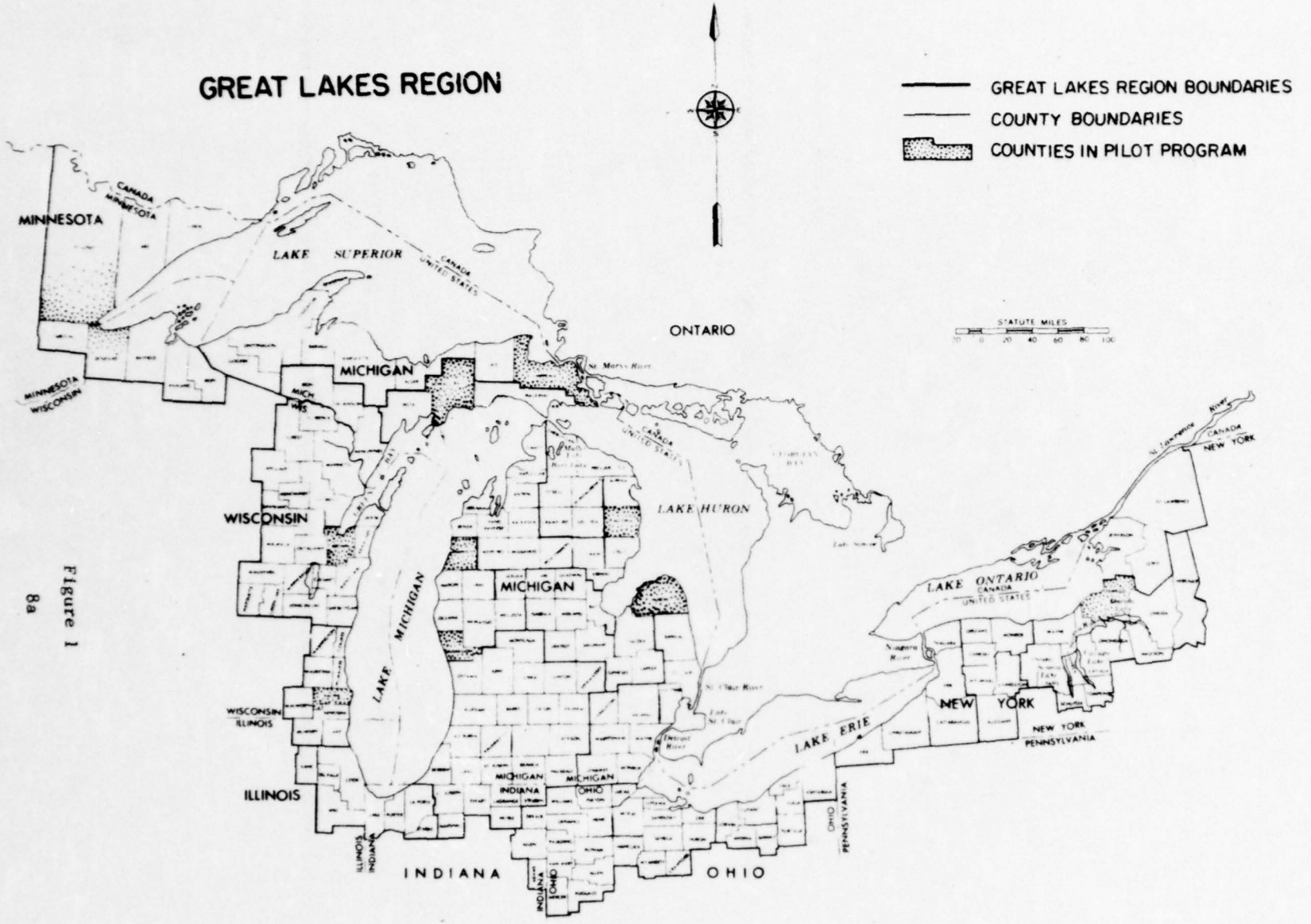
GREAT LAKES REGION
GREAT LAKES REGION BOUNDARIES
COUNTY BOUNDARIES
COUNTIES IN PILOT PROGRAM
STATUTE MILES
MINNESOTA
LAKE SUPERIOR
ONTARIO
MICHIGAN
WISCONSIN
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
NEW YORK
LAKE ERIE
ILLINOIS
INDIANA
OHIO
PENNSYLVANIA

Figure 1
8a

B. Study Program

1. The study program design was composed of the following activities:

Activity 1. PREPARE AND IMPLEMENT SURVEY CONTRACTS

Contracts for the conduct of the damage surveys were entered into with the States where the Pilot Study counties were located. The contracts were awarded by the Chicago District, Corps of Engineers, and were administered by the North Central Division. The contracts were awarded in late Fall and early Winter 1974. The states were responsible for conducting the surveys. State letterheads were used for the mail out of data collection instruments.

Activity 2. PREPARE BASE MAPS

Photomosaic base maps of the 11 Pilot Study counties were prepared by the North Central Division for use by the state contractors in compiling the data collected.

Activity 3. DETERMINE SHORELAND OWNERSHIP, VALUE, AND USE

The state contractors collected from the County Tax Assessor's Office and other sources information on the ownership and assessed value of all riparian shoreline property. This information was tabulated and coded for computer processing and preparation of mailing labels. Ownership was classified as Federal, State, Local, Public, and Private. Shoreland use classifications were residential, commercial and industrial, transportation facilities, public and private utilities, recreation and open space lands, agricultural and forest lands, and others.

Activity 4. ADMINISTER SHORELAND DAMAGE ASSESSMENT

Residential Properties

A self-administered damage assessment statement was used by the state contractors to obtain damage information from holders of riparian property located along the Great Lakes shoreline. Riparian properties are those which border along water surfaces or which are affected by fluctuations in water levels. Information requested on the assessment included:

a. location,
b. estimates of changes in market values,
c. damage estimates for the 1972-1974 study period,
d. protective actions,
e. risk from flooding,
f. risk from erosion,
g. insurance coverage,
h. correct mailing address.

The self-administered damage assessment involved a mailing of the forms to all identified lake riparian owners. Much of the data reported reflects the perceptions of property owners. Precise measurements were generally not available. This is particularly true about the estimates of beach and bluff losses. Beach losses in many cases are not permanent. Much of the loss may reflect temporary loss due to inundation. Volumetric bluff losses are typically not precise. Values for Oswego County, resulting from a professional field survey over a 15-year period of time, may be considered to be developed under a controlled and instrumented method. However, the data for Oswego is at best an estimate.

Follow-up personal interviews were administered so as to obtain representative samples from (a) non-respondents to the mail-out assessment, and (b) respondents to the mail-out assessment. Respondents were interviewed to check for statistical bias in the responses to the self-administered assessment. Damage values for interview data were slightly lower than stated in corresponding self-administered damage assessments. It was later discovered that the data thus collected was inconclusive from the standpoint of statistical tests of significance. Therefore, the aggregated values reported by respondents were not adjusted on the basis of follow-up interviews. In individual cases where respondents had made mistakes of an obvious nature, such as putting the decimal mark in the wrong place, corrections were made.

All values for the pilot counties should be regarded as estimates of magnitudes. The suggestive nature of the data should be stressed. Values reported may be sensitive to the density distribution of responses as well as the measurement error present in each response from a property owner.

Nonresidential Properties

Information was acquired from nonresidential riparian property owners through different assessment statements than those used for residential properties. Nonresidential property interests referred to here consist of:

a. Agricultural
b. Industrial and Commercial
c. Transporation
d. Utilities
e. Other

A contact letter was sent to each riparian nonresidential property listing. The letter indicated the purpose and need to acquire information concerning the potential risk and/or experienced damage resulting from erosion and flooding of the shoreland property in question. An accompanying request was made for establishing an appointment for a personal interview at which time an assessment was filled out.

Information collected in the self-administered and personal interview assessments was tabulated and reported in the following fashion:

a. Damage estimates: dollar weighted
b. Protective action: frequency tabulations
c. Risks from flooding: frequency tabulations
d. Risks from erosion: frequency tabulations
e. Estimated changes in market values: dollar weighted
f. Bluff recession: linear and volumetric measures.

Activity 5. COMPILE EFFECTIVENESS DATA ON SHORE STRUCTURES

The state contractors with Corps assistance compiled a list of existing erosion and flood protection structures and provided general evaluations of their effectiveness. An evaluation of protective structure effectiveness was obtained from the property owner in the self-administered residential assessment and during all residential and non-residential personal interviews. Using professional judgment, an independent check was made in the field of the effectiveness of shore protection structures by the state contractors. The preliminary results of this work were evaluated by the Coastal Engineering and Hydraulic Design Branch, North Central Division, Corps of Engineers. The results suggest that the information acquired under this activity is of limited value to the damage study, per se.

Activity 6. DELINEATE FLOOD PLAINS

The determination of flood damage required delineation of the in-shore areas prone to such damage. The character and extent of shoreland flood plains were initially to be defined by the establishment of high water marks and use of maps to outline the limits of the flooded areas from these elevations. This procedure proved to be unworkable as the high water marks vanished due to the time-lapse between storm events and awarding of contracts. An alternative method was used whereby the state contractors used the definition of the 100-year flood elevation for each reach of shoreline in identifying the lake flood plain. Determinations of the 100-year flood elevations were made by the Detroit District, Corps of Engineers. The 100-year flood represents the flood level that on the average will have a one percent chance of being equalled or exceeded in any given year. They were derived from a frequency analysis of the maximum instantaneous level recorded each year for the water level gage for that reach of shoreline. There are 33 gages on the United States shore which were used for the determinations. These calculations did not include wave height and run-up acting against a given shoreline profile. The 100-year flood elevations were transferred to U.S. Geological Survey topographical maps for defining the limits of the lake flooding. These boundaries were then transferred by the contractors to the Government-furnished aerial map mosaics (except for the Michigan Counties).

Some problems still existed with the definition of the lake flood plain of certain reaches on the aerial map mosaics. The mosaics were compiled from aerial photos covering only a limited width of shoreline area. Where the lake flood plain extended more than 500 feet inland,

the flood plain outline was generally not traceable onto the map mosaic. This required relying on alternative mapping references for displaying the lake flood plain boundaries.

Once the lake flood plain was defined, the residential properties subjected to the risk of lake flooding were to be identified. It was anticipated that where the lake flood extended inland more than several hundred feet, non-riparian properties would be included within the data collection sampling frame. Development of such a non-riparian sampling frame was not necessary during the pilot study. The only significant area flooding threat in the 11 counties occurred in Brown County, Wisconsin, where an alternative study method was implemented (i.e., reliance on a previous USGS study). A sampling procedure for collecting information was to be followed in contacting the nonresidential property owners situated within the lake flood plain.

Activity 7. ESTABLISH PHYSICAL PROCESSES MONITORING STATIONS

Four typical cross sections of the shore form were made by the state contractor in each Pilot County. Mechanical analyses of the bluff face material were made to define the percentages of gravel, sand, silt, and clay material. The analyses were made by the United States Environmental Protection Agency under a cooperative agreement worked out prior to the conduct of field survey work in Spring 1975. The cross sections were marked for subsequent long-term monitoring. Where long-term historic data were available such data were included in the report for each county.

Activity 8. COLLECT SUPPLEMENTARY INFORMATION

Photographs of flooding conditions, typical emergency structures, damage to structures, critical flood plain areas, and other features showing the damaging forces of waves were collected by the state contractors. Copies of pertinent newspaper articles were obtained for further documentation of damaging storms.

Readily obtainable information on the effects of high lake levels on the shoreland environment was collected and recorded by state contractors. Sources of information included state and federal conservation agencies and local managers of marinas and public and private beaches. Information from these sources was obtained through interviews and on-site observations.

Available information on wildlife-supporting marsh areas was obtained from state agencies. The effects of high lake levels on marsh and swamp lands were then to be evaluated in the report.

High lake levels were believed to restrict use and enjoyment of beaches and recreational boating facilities (although lessening costs of dredging in some cases). Losses in such recreational opportunities were to be documented. This required an inventory of beach and

boating facilities and a comparison of attendance figures in the high water period as compared to periods of lower lake levels.

Activity 9. PROCESS AND COMPILE SURVEY RESULTS

Responses contained in the completed assessments were to be available for processing and reporting in alternative ways. As many as 83 variables were defined on the ten-page self-administered residential assessment. This volume of data necessitated automated data processing by the state contractors. Data and records for each county were kept separate for subsequent processing, analysis, and preparation of individual county reports. It was required that assessments be further coded for shoreline reach coordinates within each county. This was to allow reporting of results on a more discriminate geographical basis.

Early reports by the State of Michigan contractor of the experiences in analyzing responses provided by residential property owners indicated that unusual statistical characteristics were present in some of the Pilot Survey counties. Many of the variables tested for their probability density functions were found to be "log normally" distributed. This characteristic invalidated the procedures for developing estimates of total values. Procedures defined in the state contracts for developing estimates of total values were contingent upon the variables having "normal" probability distributions. Given the "log normality" conditions, the application of the established procedures would have resulted in a positive bias to estimates of total values. A method to compensate for this problem was developed by the North Central Division, Corps of Engineers. The projection of residential shoreline totals for this summary report was computed by the following formula:

$$\frac{\text{Total value reported}}{\text{Percent of properties contacted}} = \text{Total projected value for county}$$

Activity 10. CORPS (NCD) REVIEW OF CONTRACTORS' REPORTS

The Corps of Engineers reviewed draft and revised draft copies of the contractors' reports. The draft reports were checked for consistency and for adherence to the contract requirements. In some cases, the projection of actual reported values to represent the entire county shoreline had to be completed.

2. The damage data produced by these activities will be a lump sum estimate by county for the study period (two years). In the future the data will be converted to estimates of average annual damages by the Water Control Center, Engineering Division, North Central Division, Corps of Engineers. This lump sum total will be apportioned among the 24 most severe storm events of the period by month. The seasonal water level plus the storm water level for each of these events combine to produce the "ultimate water level"

for that month. The apportioned damages corresponding to each monthly ultimate water level provide the basis to compute updated estimates of average annual damages and an updated stage-damage curve.

C. Data Collection Procedures

This section describes the data collection procedures used specifically in the St. Louis County, Minnesota, study. It is, however, typical of the study efforts in the other pilot counties (except for Huron County, Michigan).

(1) A sampling frame was developed in the beginning of the study in St. Louis County. The sampling frame was based upon county property ownership records. A total of 878 individual parcels were identified, of which 345 were classified as residential and the remaining 533 as non-residential. The residential parcel owners each received damage assessments by mail following a systematic set of procedures utilizing reminder post cards and certified second mailings to initial non-respondents. A total of 231 usable assessments were returned, a response of 67 percent.

(2) The mail responses were sorted into two sub-groups or sub-populations in order to assist in the elimination of bias and to control for measurement error. With a mail-out type assessment, it is assumed that a certain percentage of the people will not respond. In order to make inferences for this non-responding group, the bias of respondents vs. non-respondents must be taken into account and eliminated, if possible. Elimination of bias in this instance was afforded through the interviewing of non-respondents to the assessment. The interview data could then be compared with respondent data, and inferences made based on statistical testing procedures. The personal interviewing was designed to assist in the control for any measurement errors that were later found to prevail. The two sub-populations were 1) respondents whose assessments were complete and usable or partially usable, and 2) non-respondents and respondents whose assessments were incomplete and not usable.

(3) After completion of the mail-out and sorting, the respondents and non-respondents were identified and a random sample of 50 parcels were selected for follow-up personal interview. The random sample generated parcels from both sub-sets, respondents and non-respondents. Personal interviews with owners of these parcels were then attempted in order to provide data from which to make inferences about the damage conditions experienced by the group of non-respondents. Statistical tests were also undertaken to determine if there were significant differences between the respondents' mailed back assessments and their personal interviews. It was subsequently determined that the procedures prescribed for selecting follow-up

personal interviews resulted in inadequate sampling of non-respondents. This, in part, resulted from the high response rate achieved in the mail-out of self-administered assessments.

(4) All non-residential parcel owners were contacted for personal interview appointments of which 27 interviews were completed, or a 65 percent response rate. Most non-residential parcel owners hold title to multiple parcels of land; as a result, a smaller number of non-residential interviews were required than suggested by the number of parcels identified. It should be emphasized that the occupants of non-residential parcels did not receive a mail-out assessment and were only subject to interviewing. Projections were not made for those non-residential owners refusing to participate in the interview. Structured interviewing was emphasized throughout the interviewing phase to ensure consistency between responses and to control bias associated with the use of interview personnel. The interview instruments were furnished by U.S. Army Corps of Engineers and consisted of both flooding and erosion damage forms for the following land use classifications: residential, commercial/industrial, utility, transportation, and agriculture. Students having a geology background were employed from the University of Minnesota, Duluth to conduct the personal interviews and field reconnaissance.

(5) The processing of information supplied by the various instruments was computerized for the residential properties and hand tabulated for non-residential properties because of their relatively small number.

The Statistical Package for the Social Sciences (SPSS) 1/ computer programming language was used for data processing. The system was adopted for the summary and analysis of the data. More importantly, comparison of cross-tabulations of variables from different records and alterations to record controls were accomplished quickly with the use of a minimum number of data entry or control cards. (The University of Michigan, Coastal Zone Laboratory used the MIDAS statistical package for the automated data processing of respondents' information for the other 10 counties).

(6) Data analysis was begun by comparing damage and descriptive values reported by the three county subpopulations. This provided information needed for projecting estimates for the entire residential shoreline population. The three sub-populations identified for parameter testing were: (1) respondents to the self-administered mail-out assessment, (2) respondents to the follow-up personal interview of respondents to the assessment, and (3) respondents to the

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1/ Statistical Package for the Social Sciences, Norman H. Nie, Dale H. Bent, and C. Hadlan Hull, Copyright 1970, by McGraw Hill, Inc.

follow-up personal interview of non-respondents to the mail-out assessment. A total of 50 interviews were randomly selected from the groups of respondents and non-respondents. Of this total, 30 were completed with 28 of 38 returned by the second sub-population class and 2 of 12 from the third sub-population. The small number of responses obtained from the third sub-population prevented making meaningful statistical comparisons between non-respondents and respondents for this county. During attempts to interview non-respondents in St. Louis County, it was generally found that property owners were unwilling to cooperate. In other instances parcel owners were out of town or absentee landlords who indicated they were not capable of addressing specific questions regarding damage conditions.

(7) Statistical Analysis

(a) Some accuracy in statistical projections can be lost if samples are drawn from non-normal sub-populations. Non-normality, however, does not result in a sample mean being a biased estimator of the population mean. "It can be shown for example, that the average value of the sample mean taken over all possible samples of the same size is equal to the population mean regardless of the form of the population." 1/ Nevertheless, the common properties of non-normality, skewness and kurtosis 2/ increase the variance of the estimator of the sample variance, and therefore reduce the accuracy of results.

(b) The sample populations of the critical variables analyzed in this report were investigated to ascertain the degree of non-normality present. To accomplish this objective, the following steps were undertaken:

1. Histograms were drawn for the critical variables.

2. Skewness and kurtosis estimates were obtained from the statistical program employed in analyzing the data.

3. The significance level of these coefficients was assessed.

4. A log transformation was undertaken for each of the variables analyzed.

1/ Elements of Statistical Inference, David B. Huntsburger, Allyn & Bacon, Boston, Mass., 1967, p. 141.

2/ Statistical Methods, George W. Snedecor and William C. Cochran, The Iowa State University Press, Ames, Iowa, 1967, p. 89.

5. The skewness and kurtosis estimates were analyzed as to their statistical significance.

Histograms were chosen for representation of variables because they typify the types of sample population that were encountered. It was observed that the histograms indicated that the populations may conform more closely to a log normal distribution than to a normal distribution.

(c) Values for skewness and kurtosis were obtained for six variables in two areas of the county shoreline (see Table 1). It was found that all the variables had a significant level of skewness, and all but one were significant at the one percent or better significance level and the remaining one was significant at the five percent level. The kurtosis coefficient was somewhat less consistent. Nine of the twelve kurtosis readings showed significance at the one percent level, two at the five percent level, and one reading showed no significant kurtosis.

(d) Log transformation of the data did reduce some of the distortion present. After the transformation, only three of the twelve readings had a significant level of skewness. The kurtosis factor, however, worsened. After transformation, all of the 12 readings had significant levels of kurtosis at the one percent significance level. The Minnesota contractor concluded that a log transformation does not eliminate the distortion problems inherent in the sampling distributions. Whether or not the projections could be improved through this type of transformation, is not obvious from the results that were obtained. Further statistical analysis is necessary to make this determination.

(e) The data from which the projections were made is available if it is decided that additional statistical refinements are warranted at a later date.

The value of such refinements is dependent on the overall accuracy of the testing process that was undertaken. The total error of this process is comprised of a sampling component and a statistical component. If it is determined that the statistical component is large in relation to the sampling component, then analysis through more advanced statistical techniques may be warranted or a larger sample obtained. It should be noted that other parametric and non-parametric tests were undertaken to compare the means and medians of data subsets of the variables tested.

TABLE 1

STATISTICAL PROPERTIES OF SELECTED VARIABLES

		REGULAR DATA		LOG TRANSFORMED DATA	
Variables	Sample Size	Skewness	Kurtosis	Skewness	Kurtosis
Area One					
Erosion Damage	25	1,444**	1,987**-	.088	-1.058**-
Flood Damage	33	1,942**	3,191	.008	- .991**-
Protective Action					
Materials	26	.594	- .972	- .709	.602**-
Labor	32	2.635**	7.809**+	.043	- .621**-
Bluff Volume Lost	19	1.825**	2.198*-	.180	- .501**-
Reach Area Lost	13	2.351**	4.077*+	1.409**	.825**-
Area Two					
Erosion Damage	50	2.728**	7.895**+	.082	- .647**-
Flood Damage	28	.921*	- .639**-	- .471	- .845**-
Protective Action					
Materials	22	2.643**	7.065**+	- .017	- .950**-
Labor	20	1.357**	1.538**-	- .285	-1.278**-
Bluff Volume Lost	70	6.605**	45.857**+	1.125**	1.719**-
Beach Area Lost	80	6.614**	47.611**+	1.029**	1.281**-

* 5% Significance
** 1% Significance

0 - Skewness Normal

3 - Kurtosis Normal

SECTION IV

STATISTICAL EVALUATION

An appraisal of the data collection techniques and statistical procedures was made by Dr. E. D. Rothman of the Department of Statistics, University of Michigan. Dr. Rothman analyzed data collected in the Michigan counties. This appraisal has been printed as Appendix V of this report. Among Dr. Rothman's conclusions were:

(1) Use of the Lognormal Approximation

a. The sample mean and variance of a variable which is approximately lognormal provide misleading information regarding shape and skewness of the variable's distribution. However, the mean and variance of the log of the variable describe the variable's distribution completely.

b. Since the log of a variable which is approximately lognormal is approximately normal, the log of a lognormal type variable may be appropriately used in all statistical procedures based on the assumption of normality. Such procedures used during the course of this analysis include: regression analysis, paired and two-sample t-tests, and analysis of variance.

c. Lognormal models can be used to construct tolerance intervals and estimate population proportions within specified ranges.

d. Lognormal fits within individual reaches for the ten lognormal type variables were good when reaches were large enough. For small reaches he suggested that a census be taken so that fitting a distribution is not necessary.

(2) Outliers

All outliers (extreme values listed by respondents) should be carefully checked for coding errors, keypunching or typing errors, and response errors. A call or visit to respondent may be necessary to check the validity of a response if an outlier is found not to be the result of a clerical error.

(3) Mailed Assessment vs. Personal Interview

a. No statistically significant differences between responses to mailed assessments and personal interviews for survey information obtained in Muskegon County, Michigan, were found for variables tested.

b. When measures of central tendency for mailed assessment and interview data were compared, respondents were found generally to give somewhat higher (although not statistically significant) answers on the mailed assessment than during the interview for all

four damage and loss variables: total damage, total cost, bluff loss, and beach loss.

c. The presence of an interviewer seems to have a conservative effect on answers to many questions. (However, other state contractors felt that the influence of a personal interviewer had varying effects on values reported).

(4) Respondents vs. Non-respondents

a. No statistically significant differences between answers given by respondents and non-respondents in the personal interview setting could be found for the variables tested. (There were significant differences, but they were inconsistent over a range of parameters).

b. When measures of central tendency for respondents and non-respondents were compared, respondents were found generally to give larger answers for property worth, property depth, beach depth, and total cost than did non-respondents. Non-respondents tended to report greater beach and bluff losses. Thus, these results indicate that non-respondents tend to have smaller, less valuable properties than respondents, but to have suffered greater beach and bluff losses from the high lake levels.

SECTION V

BENEFIT/COST MODEL FOR SHORE PROTECTION SYSTEMS

This study was conducted by the Coastal Zone Laboratory of the University of Michigan. It is included as Appendix VI of this report and is synopized below.

The decision to invest in a shore protection structure is influenced by a number of variables, which are interrelated and make any intuitive approach to decision-making difficult. To enable shoreline property owners to examine the many and various factors involved in making investments in shoreline protective structures, the study employs benefit/cost analysis. This economic tool evaluates the net benefits property owners derive from shoreline structures. The estimated net benefits to be derived from a protective structure are influenced by many factors such as property values; the effectiveness of protective structures; lake level fluctuations; etc. The final model ties together these complex factors in a computer program that determines the economic worth of the various protective measures available.

To illustrate the value of the model for decision making regarding shoreline protective measures, an example is provided. A property in West Olive, Michigan, undergoing severe bluff erosion (13 feet per year) was selected. The house on this property is 75 feet from the edge of the bluff, and there is a potential danger of damage in the future. A shoreline protective structure will prevent further bluff recession to some extent, and thus decrease the danger of damage to this home. The protection of the house from damage, and the prevention of property value decline due to bluff recession are conceived as the benefits accruing to a shoreline protective structure. The manner in which property values decline as the bluff recedes is analyzed.

Future benefits and costs resulting from protective measures are brought to present worth by calculating the opportunity cost of waiting for net benefits to accrue to the property owners. Thus, at the time the structure is built no benefits have accrued, but the initial costs of building the structure have been incurred. In this example, a wooden groin is constructed which has an initial cost of $60 per front foot of shoreline property. This translates into a present value of -$60 per front foot in year 0. After the groin has been in existence for one year the net benefit has increased to -$32.92 per front foot because the groin has reduced bluff erosion and the associated property value decline. By the end of the second year the net benefits are positive ($22.75 per front foot) as a result of further reduction of bluff loss. After ten years the wooden groin would yield the shoreline property owner a present value

of $29.78 per front foot. The present value of the structure after ten years is used for comparison purposes with other structures, because some short-term structures may have a high initial effectiveness, but provide no long-term benefits. In this example the present value of a timber seawall after ten years is $98.41 per front foot, even though the structure fails after six years. A steel seawall yields $47.52 per front foot after ten years. A sandbag groin had a present value of -$49.42 per front foot, and stone revetment -$4.12 per front foot.

This model shows that some protective measures are not 100 percent effective over ten years by reducing the benefits as those structures become less effective. If a protective structure is not 100 percent effective, bluff recession will continue, if only to a minor extent, and therefore there will be some loss in property value. By the same token, we may expect lake levels to decline at some time within the next ten years, and therefore bluff recession will be reduced. The model accounts for any decline in bluff recession rates to the extent that we can predict lake level fluctuations.

The benefit/cost model also estimates the net benefits of moving a home back from the bluff, an alternative to building a shoreline protective structure. A prerequisite to home moving is that the lot be deep enough to move the home an adequate distance to ensure that there will be no danger of damage within the near future. The cost of moving the house in this example would be $60 per front foot, but the present value of such a move is $104.54 per front foot. The home moving option had the highest present value of any of the alternatives studied, and therefore the property owner, making a rational economic decision, would want to move his home. The owner's opinion of the value of that property is probably much higher than the market value. Such subjective values are very important, and may be the decisive factors in determining how much is invested in shoreline protection.

This study, however, concentrates on market value for two reasons:

1. It is not possible to account for each individual's values regarding shoreline property.

2. An individual can take the recommendations of this economic analysis and alter them according to his personal preferences.

It is assumed that each shoreline property owner is an entrepreneur seeking to maximize the return on his investment in shoreline property. Given the value of an individual property, the rates of recession, etc., the amount of money that should be invested in a shoreline protective structure will be defined so that the property

value saved by protection against erosion justifies the cost of a shoreline protection structure. Consequently, a property owner would be able to sell his property at a price which is now greater by at least the cost of the shoreline protection structure than if erosion had continued unimpeded. Thus, the investment dictated by the market (if any) would be the minimum that a property owner would expend. This analysis will provide shoreline property owners with a framework for making rational decisions concerning protective structures.

The report discusses in detail the major elements of the model. Various hypothetical examples are used to explain the operation of the model. However, the reader should note that the main purpose of this first phase of the study was to produce a model upon which future improvements and refinements could be made.

SECTION VI

COMPARISON OF FIELD DATA COLLECTION TO DATA COLLECTED USING STUDY INSTRUMENTS IN MUSKEGON AND MANISTEE COUNTIES, MICHIGAN

The Coastal Zone Laboratory of the University of Michigan conducted tests in Muskegon and Manistee Counties to compare homeowner perceptions reflected in the self-administered damage assessment with independent measurements. This study has been printed as Appendix VIII and is summarized below.

Data was collected from a sample of county homeowners in the following categories: present property worth, bluff height, and the distance from the bluff edge to the foundation of the house. These parameters were chosen because they typify homeowners perceptions of monetary value, vertical distance, and horizontal distance, respectively. The present property worth was evaluated by a local realtor, making his assessment of the property value by looking at the exterior of the home and the grounds. Bluff height and distance from bluff edge to foundation were measured at the site. Bluff height was not measured directly, but was calculated from the slope of the bluff face and the horizontal distance from bluff edge to beach. The data was compiled for each county and paired with the corresponding self-administered assessments and with the appropriate personal interviews. Some of these comparisons are presented in Table 2.

TABLE 2

DATA COMPARISON

Parameter	Muskegon County Mean	Muskegon County Mean Difference	Manistee County Mean	Manistee County Mean Difference
Property worth-SAA 1/	35095	2972	43700	27845
Property worth-IM	32123		71545	
Property worth-PI	31507	2213	29877	3469
Property worth-IM	33720		33346	
Bluff height-SAA	37.8	41.4	21.1	29.6
Bluff height-IM	79.2		50.7	
Bluff height-PI	40.9	9.5	23.6	17.4
Bluff height-IM	50.4		41.0	
Bluff to foundation-SAA	75.2	4.6	70.3	37.6
Bluff to foundation-IM	70.6		32.7	
Bluff to foundation-PI	73.2	48.8	59.7	8.7
Bluff to foundation-IM	24.4		68.4	

1/ SAA = Self-Administered Assessment
PI = Personal Interview
IM = Independent Measurements

Each paired set of data was then analyzed statistically. This analysis is presented in Appendix VIII.

SECTION VII

SAMPLING PROCEDURE (HURON COUNTY STUDY)

Huron County was one of six counties selected for pilot damage assessment studies in the State of Michigan. This county, unlike the five other pilot counties which used a census format for data gathering, was selected to use a sampling procedure for obtaining the data. The purpose of using a sampling procedure was to test the feasibility of gathering information more efficiently. The information to be gathered was to be of equal reliability but obtained at a reduced cost.

As with all counties in the pilot study program, Huron County was divided into reaches. The reach delineations were established by controlling parameters of bluff type, natural or man-made features which might be expected to influence coastal processes, and land use. The first two parameters were given more weight than the last one. Using this criteria, Huron County was stratified into five reaches. (See Section 2.2 in Appendix III for a description of these reaches.)

Most counties in this study did not have legal tax records which easily allowed for the identification of the shoreland owners. Even the use of plat maps, when available, did not make this task simple. To determine the ownership of Huron County shorelands it was necessary to obtain the legal descriptions for all the properties in sections which were bounded by the open coast shoreline. These legal descriptions then had to be read along with the available plat maps to determine which properties were actually on the shoreline. The legal records of the shoreline properties contain the owner's name, a description of the property, the property's assessed value, the date the assessment was made, and the mailing address for the tax bill. These tax records do not give the shoreline property mailing address (unless the tax bill is sent to that address) or the land use.

There were a number of problems with the legal descriptions themselves in Huron County. The three most prevalent difficulties will be described and illustrated with an example. First, many properties were described where they could not possibly be located. For example, a property would be sited in a section, which in turn would be located out in the lake proper. Second, some properties were defined with vague or unusual legal descriptions which hindered determining the precise location of the property. For example, legal descriptions were found which only said, "No street lights. Personal." Finally, some properties were not referenced in a manner so that their location could be determined. For example, two properties would be described as follows: for property A, 'Property A is located next to Property B' and the description of property B would say, 'Property B is located next to Property A'.

Another problem with the tax record information involved land use determinations. Since the property descriptions do not give the land use, the only possible way to determine whether a property is used for commercial/industrial purposes or is governmental land is to review the owner's "name". There are "clues" in the legal descriptions that might let this determination be made. For example, institutional designations such as "incorporated" for commercial/industrial or "State of Michigan" for governmental aided in such a determination. An alternative way of determining land use would be to actually walk and map the shoreline. This latter task was not done as it is very expensive and outside the scope of this study. In addition, walks by the shoreline will not reveal undeveloped tracts of land which are in commercial/industrial holding, so the former task was used to separate the residential owners from the entire listing of shoreland owners. This method of separating the classes of shoreland owners has some additional problems in that many times a "residential" piece of property is owned by a corporation and thus, this property would be included in the commercial/industrial list. If this difficulty were uncovered during the course of the assessment in the other counties studied, the property would be dropped from the commercial/industrial list and the owner was sent a residential questionnaire. This, of course, was not possible in Huron County since the residential owners were being sampled and "errors" were not detected until after the sampling process was well underway. Also, a property which would appear to be residential in the tax listings would actually be used for rental cottages. This should have been included in the commercial/industrial list. Fortunately, the self-administered assessment allowed for the capturing of information of this type of property --it simply was not summed in the appropriate table.

With the limits outlined above, lists of residential owners were established for each of the five reaches in Huron County. As required, 15 percent of the residential property owners in each reach were randomly selected with the exception of the owners in Reach 5. A 15 percent sampling in Reach 5 was less than 25 residential owners (the minimum required), thus, 25 property owners were randomly selected in this reach. Those owners selected in the sample received a self-administered assessment and reminders, following the same mail sequence as owners in other counties under study. These shoreland owners received a slightly different letter than those owners in the other pilot counties. The letter sent to the owners in Huron County emphasized that they were specially selected in a sample and thus their responses were very important.

The response rate for Huron County was 73 percent which was slightly above the average response rate (69 percent) for the other counties under study. It has not been determined if this slight increase is statistically significant. It has also not been determined if the response rate was higher because of the "different"

letter sent or because the shoreline owners were subjected to conditions different from shoreline owners in other counties which might make them more inclined to respond.

Results from this sampling procedure provided results which agreed very favorably with the information collected in other Michigan pilot counties (see Appendix V, Shoreline Damage Survey: An Appraisal with Recommendations). This reveals that the capturing of the same level of significant results is possible using a sampling technique in lieu of the census style approach, and at a substantial saving.

Basic data results are presented later in the report. Expanded totals for some values for this county (and its reaches) are given in Appendix V.

Interviews of respondents and non-respondents were conducted in Huron County. Forty-six property owners from the sample were randomly selected for personal interviews, 35 respondents and 11 non-respondents.

It had been observed in the counties studied that non-respondents were the most difficult to interview if a phone listing could not be readily obtained. For this reason, if a phone listing for a non-respondent could not be obtained in either Huron County or the area where the tax bill was sent, a new non-respondent was randomly selected. Of the 11 non-respondents in the interview sample, nine were successfully interviewed. One person was found not to live on the lake and the last person was found to have sold his property and the new owner could not complete the interview. This was unusually successful in terms of a response rate for non-respondents. Comparing the difficulties experienced in the other study counties to the good results in this county implies that by limiting contact to non-respondents with readily available phone listings will give a high completion rate for personal interviews. What bias, if any, is introduced by doing this is not known.

Four respondents were not able to provide completed interviews. The reason for this was that generally after four attempts to contact the respondent, no further attempts were made to complete the interview. The level of contact for respondents in personal interviews in Huron County was about the same as that of the other counties in the study in Michigan.

SECTION VIII

MEASUREMENT OF COASTAL BLUFF RECESSION FROM AERIAL PHOTOGRAPHS, MUSKEGON COUNTY, MICHIGAN

This study, which is included as Appendix VII, was undertaken to evaluate the usefulness of aerial photographs in the determination of coastal erosion rates. The effectiveness of aerial photographs was examined in terms of availability, type of coverage, and the reliability of the measurements obtained from the photographs. The procedure was to locate existing aerial photographs of Muskegon County, selecting and obtaining those pertinent to the erosion areas. Further steps involved selecting tentative site locations, making field observations and ground measurements, taking photograph measurements and deriving erosion rate calculations.

Aerial photographs are not planimetric maps; thus the possibility of distortions must always be kept in mind if accurate measurements are to be obtained. Critical errors in photographs are due to relief displacement, tilt error, measurement error, and interpretation error. The first two errors are expressed in non-linear scale variations in the image. Measurement errors involve the precision of the measuring tool. Interpretation errors vary with the quality of the photographs, their date and scale, and the skills of the interpreter. Methods were incorporated to reduce errors caused by these problems.

Location errors arose due to lack of stereo coverage, poor edge gradients, poor tone contrasts, rounded beach profiles, and dense foliage. Sites must be selected that avoid these problems if errors are to be minimized. Location errors were most common with toe line measurements, generally due to over exposure of the bright sandy beach area. Shape ambiguities were also common at toe lines, and poor toe line measurements commonly gave incorrect beach width data. It was felt that the time spent measuring toe lines is not worthwhile because of the frequency of these location errors. Sand bar line measurements indicated that the center of the first bar was generally about 200 feet from the water line, although distances in 1970 ranged from 79 feet to 558 feet.

Not enough sites were measured to make broad correlations on coastal dynamics between sites. Even after a reliable method of measurement is developed, the non-linear nature of coastal processes in both time and space relationships must be dealt with. A random or uniform sampling program must be set up in order to give a representative recession rate along an entire stretch; widely spaced measurements cannot produce similar results. Site spacing may have to be as close as 100 feet before correlations along a stretch of beach can be made. Coastal processes are perhaps even less linear

in relation to time than in the spatial sense. Recession rates over long time intervals give only grand averages. However, due to the non-linear nature of coastal processes, it is very possible that only a few storms or a few years of high water could cause the greater part of the recession. Therefore, averaging over many years tends to mask the dynamic nature of coastal processes. The methods used in this study can produce useful data for ideal sites, that is, sites with no location error problems and good scale control points.

The most accurate methods for recession studies require first order plotting instruments using advanced photogrammetric techniques. The costs involved here would by far outweigh any practical application of the information. If imagery is to be flown for work on coastal studies, it is recommended that it be at a scale of at least 1:10,000 and flown in early spring when foliage does not block the view. The line of flight should be parallel to the coast, placing the coast in the center of the photographs to minimize relief displacement and show plenty of land for good scale control points.

The report indicates that recession rates cannot be quantified to the desired degree. Only "ball park" values of rates can be obtained under two possible situations using aerial photography: when a great deal of erosion occurs over a short period of time, or when measurements are made over a long time interval. Indications of rapid recession over a short time interval can usually be detected by simple observation of the aerial photographs.

Some important criteria for selecting scale control points and site locations are listed below. Most are required to minimize errors, but others are suggested to avoid common pitfalls.

1. Select scale control points as close to the shore as possible.

2. The scale control line should be parallel or close to parallel to the direction in which bluff line measurements will be made. This means perpendicular to the coast.

3. The elevation of scale control points should be close to the elevation of the coastal area.

4. Each control point should be a distinct, permanent geographic location.

5. Each control point must be clearly visible in each year of coverage.

6. Good stereo coverage for each site is essential.

7. Selected controls should not vary with the seasons. For example, many times distinct controls in a spring photo will be covered with foliage in summer images.

8. Each site should be located near the center of at least one photo for each year of coverage.

9. Scale control points should be selected that are easily accessible and close enough for quick measurement, ideally no greater than 500 feet. Driveways are commonly the best.

10. Measure to the center of roads since they are more permanent than shoulders.

SECTION IX

SOIL SAMPLING

Mechanical analyses of the soil materials eroded from the shoreline bluffs were desired to assess the environmental effects of the eroding bluffs. In addition, soil information gained from the pilot study experience was to be used in developing sediment transport study proposals prepared under other Corps study authorities. During the early study coordination activities, it was determined that overlapping objectives existed between this study and an International Joint Commission study of Pollution From Land Use Activities. A Pollution From Land Use Activities Reference Group was formed under the leadership of the IJC (PLUARG). Study agreements were worked out between the Corps of Engineers and the PLUARG, Task Group D Team Leader, the Environmental Protection Agency (EPA), Region V Laboratory. The Corps of Engineers accepted responsibility for collecting soil samples in the 11 pilot study counties; EPA agreed to undertake the soil analyses. These analyses were more exhaustive than those planned by the Corps of Engineers; they included extensive chemical analyses in addition to mechanical analyses. The results of the EPA soil analyses have been furnished to, and are on deposit at, the North Central Division Corps of Engineers. Formal presentation of the results of the EPA soil analyses will be published in a PLUARG Task D Group report.

SECTION X

EVALUATION OF SHORELAND DAMAGES

The damage data collection procedures attempted to differentiate erosion losses from flood losses. Although sometimes difficult to separate, erosion losses are those which occur because of wave action cutting away the shore material, and flood damages result from inundation of low lying areas. Many individuals and groups have taken protective action against erosion and flooding. These actions have been of varying effectiveness. Estimated expenditures for protective measures taken during the study period were also obtained. A summary of the damage survey for each of the 11 counties in the pilot program follows:

A. Minnesota - St. Louis County

1. Physical Description

A diversity of landform types accounts for the seeming complexity and singular uniqueness of erosion problems facing property owenrs along the 69.8 miles (111.7 km) of St. Louis County (Minnesota) coastal frontage with Lake Superior. This segment of Minnesota's North Shore (total length of approximately 163 miles - 260.8 km) comprises the westernmost one-third of the littoral zone extending from the St. Louis River, adjacent to the U.S. Steel Industrial Site at Gary-New Duluth, northeastward to the St. Louis County/Lake County line. It was arbitrarily determined that the Spirit Lake portion of the St. Louis River estuary represented the uppermost reaches, where rising levels in Lake Superior would have an impact. Such a determination is subjective, although it is felt that this evaluation is in accordance with the real situation.

Contrasted with the variations in landform are additional parameters involving differences in bedrock, soils, beach materials, exposure to wave attack, and levels of erodibility. The sum total of these conditions as they exist today account for the bulk of erosion problems affecting the westernmost Lake Superior region and the environmental and developmental limitations placed upon this landscape. Both residential and non-residential property are directly affected by these conditions. The primary purpose of the survey conducted by the Arrowhead Regional Development Commission was to inventory the direct and indirect effects of rising water levels on Lake Superior. Existing shoreforms and property have become increasingly vulnerable as the lake level has increased because of above average precipitation in the basin and partially because of reduced outflow at the controlling works in the St. Marys River to limit "downstream" lake stages. Impacted areas treated

by this investigation extend from the south 1/2 of Section 35, T 49N, R 15W, West Duluth quadrangle, to the NE 1/4 of Section 36, T 52N, R 12W (Knife River USGS quandrangle). For the purposes of geological discussion, the St. Louis County shoreline (extending northeast-southwest from 46 degrees 40 minutes North Latitude to 47 degrees North Latitude and centering on 92 degrees West Longitude) has been divided into four Reaches, three of which possess distinct natural qualities and limited riparian development. The remaining sector lies wihtin the Duluth Harbor area and represents extensive shoreland modification. It also contains most of the area shore protective devices.

The Koppen-Geiger system of climatic classification places Duluth and the North Shore in the Df zone, characterized by cool annual mean temperatures (average mean annual temperature 39.5 degrees F.), sufficient precipitation in all months (average annual mean 28.33 inches), and considerable variability in temperatures from day to day. During 974, there were totals of 10,063 Heating Degree Days (Solar Insolation vs. Escaping Radiation) and 149 Cooling Degree Days. The prevailing wind pattern is from the northeast. Regions immediately adjacent to Lake Superior undergo significant temperature modification; however, there is little evidence that the presence of the Lake increases annual precipitation. Average dates of the first and last killing frost are May 13th and October 3rd, respectively.

Duluth's location near the geographic center of North America accounts for general climatic conditions; yet the existence of the lake and nearby landforms influences local temperatures markedly. Orographic lifting and/or the subsidence of air masses near the lake causes Duluth and the North Shore to be shrouded in fog an average of over 50 days per year. Despite high relative humidity throughout the warmer seasons, area residents experience less discomfort than migth be expected because few days attain temperatures greater than 80 degrees.

A highly generalized description of landscape geomorphology and the forces that have contributed to shoreline development as it exists follows:

Geology: The study area includes four areas (Reaches) of distinctly separate morphology which will be discussed in turn. The Reaches themselves were selected because they represented coastal sections of distinct origin and present landform continuity. Although the Reach boundaries are arbitrary, the uniqueness of each provides a basis for study.

Located within the study area is the City of Duluth and a ribbon residential district, running northeastward along the lakeshore. Roads constructed along the Duluth waterfront and the stretch of old U.S. Highway 61 constitute the most visible development along the shore. Despite marked differences in the nature of shoreforms, the topographic relief of these features is comparatively uniform. Soils

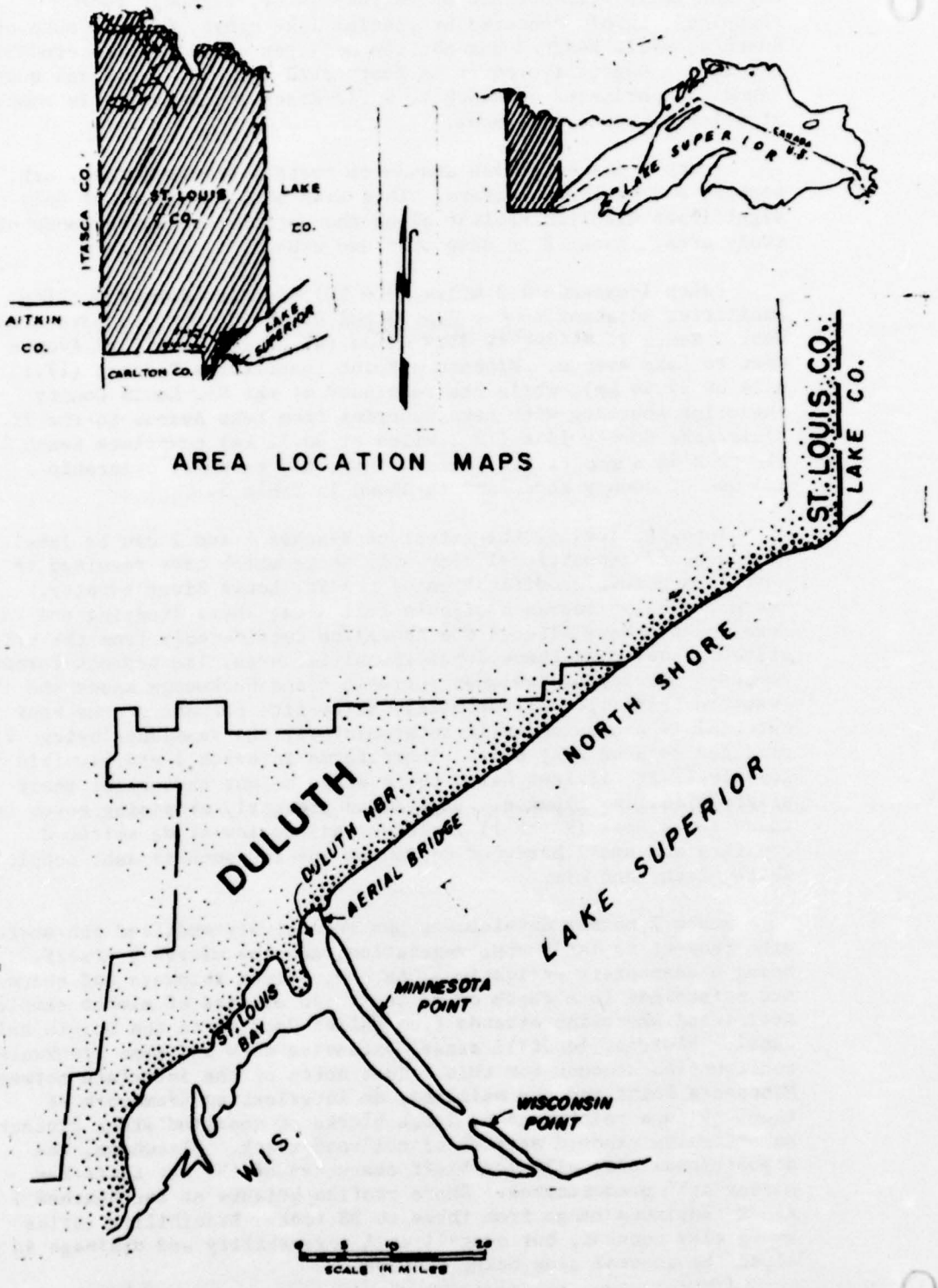
are generally well-drained where they exist, although rock croppings, thinly veneered by glacial lake clays, make up much of Reach 4, while Reach 3 has not top soil per se within its erodible environs. Begetative cover is restricted to small trees and bushes along the perimeter of Reach 4, while Reach 3 vegetation is comprised of cultural types of floral.

Reach 1 has extensive stands of certain species; i.e., ash, popple, and various conifers. This area also provides the only significant wildlife habitat along the entire riparian expanse of the study area. Reach 2 is developed and urban.

Reach 1 extends 7.5 miles (9.9 km) from the former docking facilities adjacent to the U.S. Steel Plant in Gary, to 63rd Avenue West. Reach 2 stretches 25.9 miles (41.44 km) from 63rd Avenue West to Lake Avenue. Minnesota Point constitutes Reach 3 (17.15 mils or 27.44 km), while the remainder of the St. Louis County shoreline abutting with Lake Superior from Lake Avenue to the St. Louis/Lake County line (19.2 miles or 30.72 km) comprises Reach 4. Figure 2 is a map of St. Louis County, and property ownership and use of county shoreland is shown in Table 3.

Topographically, the extent of Reaches 1 and 2 can be labeled as low-bluff depositional clay silt banks which have resulted in part from natural modification of the St. Louis River estuary. Reach 2 also possesses a sizable fill area, where dredging and harbor developments have altered the shoreline considerably from the original state. Underlying these depositional features, lie bedrock formations composed of dipping Keweenan intrusions and Puckwunge sandstone (western Reach 1). Approximately fifty-five percent of the bank material is a clay and silt inter-mixture, the remainder being sand and rock or clay silt. Shore forms in Reach 1 are erodible low-bluff with 17 feet being the average height throughout their slightly rolling expanse. Vegetation presently providing cover on these low slopes (Reach 1) includes various low-grade softwood conifers and small hardwood deciduous species such as ash, popple, white birch, and elm.

Reach 2 harbor development has extensively modified the shoreline with respect to landforms, vegetation, and the waterway itself. Being a deep-draft navigational harbor, Duluth shipways and channels are maintained to a depth of 27 feet. An expanse of almost completely artificial shoreline extends from Hallet Dock #5 to the Duluth ship canal. Sluices, landfill areas, extensive dock and some breakwater construction account for this. Just north of the interface between Minnesota Point and the mainland, an interlocking framework of steel pilings reinforced by large blocks of quarried stone protect an otherwise exposed stretch of railroad track. Elsewhere, the depositional clay silt low-bluff character of the St. Louis Bay harbor area predominates. Shore profile heights at the Reaches 1 and 2 continuum range from three to 28 feet. Erodibility varies as to clay content, but overall soil permeability and drainage is good along the coastal zone being surveyed.



AREA LOCATION MAPS

ST. LOUIS COUNTY, MINNESOTA

Figure 2

Reach 3 is composed of Minnesota Point, one portion of the large sand spit which has formed at the juncture of the north and south shores of Lake Superior. The existence of this protective barrier has posed some problems in the past due to its environmentally fragile nature and the attempts taken in the past to develop the area. Longshore drifts of sand built and nourished the Point until groins were built at the Superior and Duluth Harbor entrances. Subsequently, Minnesota Point, between the two ship canals, has suffered shoreline regression resulting from a combination of sand flow obstruction by the groin structures and continual lateral movement of beach materials. Presently, the area affected by this outflow of beach materials extends 3,000 feet southeastward of the Duluth ship canal. Dredged materials placed along this eroding coastal section in 1963, have since eroded, and a continuing program of beach nourishment and up-grading will be necessary if this beach is to be preserved. The Army Corps of Engineers has also suggested the need for modification of present land use development plans affecting this area as drawn up by the City of Duluth Research and Planning Department.1/

So long as general lake circulation continues in its present pattern, the balance between sand and water should continue to remain near an equilibrium. Recurrent storms pose problems for certain riparian property owners, due to a lack of wave built beach forms which normally would serve as a protective feature. Low-standing sand mounds are often created during the winter and spring break-up period when ice flows, which normally move across the lake, are rafted up onto the Point by storm processes. Ridges and ice-pushed mounds result, which are easily eroded by subsequent summer gales; the effect of this is an inundation of sorted beach materials with coarser materials and driftwood. Lateral gradation in mean particle size is evident on the Point, yet the greatest quantity of beach and sand is medium to coarsely-medium in particle size (2.0 to .5 Wentworth size classification) as is characteristic of a beach with a 5 to 7 degree slope. Serving as the principle mechanism in the sorting of beach materials are translittoral waves associated with small swells produced by normal weather and current circulation. Oscillatory waves result from major storms on Lake Superior and constitute the principal erosive threat to this unprotected coastline.

The North Shore of Lake Superior is one of the world's truly unique fresh water coasts resulting from the process of volcanism The Duluth-Gabbro complex dominates the skyline (600-700 feet above

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1/ Section III Detailed Project Report; Beach Erosion Control on Minnesota Point at Duluth, Minnesota, U.S. Army Corps, November 1974, p. 30.

the lake level) along the harbor frontage. A low rock shoreline fronts the lake from Minnesota Point through the extent of Reach 4. Keweenan intrusives (principally basalt) interposed by diabase sills, form a low-bluff, non-erodible shoreline. Little evidence of shoreline revetments or other protective measures in the past seems to indicate that this coastal zone was essentially non-erodible, although zig-zag rock facies show that the various intrusive outcroppings have different weathering qualities. Small coves, spurs, and pebbly beaches form the anterior coastal sections, the upper reaches of some areas being variegated by a thin residual of lake clays. Northern sections of the coastline in St. Louis County display unconsolidated clay bluffs set back a distance of approximately 50 feet from the underlying coastal bedrock. Massive slumping and mass wasting is causing the undermining of trees and brush along the lakeward bluff perimeters. This substantiates the fact that erosion exists, the primary cause being wave activity (oscillatory waves), although surficial run-off is an important element in the final erosion of weakened coastal features. Surficial erosion is not as rapid as erosion caused by wave activity, although it is beginning to take its toll in regard to property damages. Frost, wave action, and the hydraulic movements of boulders and larger beach materials can be stated as the salient factors responsible for erosion on the North Shore.

2. Nature and Extent of Physical Losses

Almost two-thirds of the residential and non-residential parcels along the St. Louis County shoreline have been subjected to either erosion flooding or both. It was found that 63 percent of residential lands (1) have been protected to combat problem conditions, (2) have sustained actual damages, or (3) are subject to risk from erosion or flooding. Erosion was the most threatening form of damage, afflicting 41 percent of the total 345 residential parcels. Flooding affected 6 percent of the properties, and both flooding and erosion totalled 16 percent (52 parcels).

TABLE 3 :
SUMMARY OF GREAT LAKES SHORELINE USE, OWNERSHIP, VALUE & PROBLEM IDENTIFICATION

ST. LOUIS COUNTY, MINNESOTA

Labor Day 1972-
Labor Day 1974

Shoreland Use	Miles Shore-land	Ownership				Aver. Assess. Value/front Foot	Problem Identification						Not subject to Erosion or Flood Damages
							Subject to Erosion			Subject to Flooding			
		Federal	State	Local	Priv.		Permanent Protection	Expedient Protection	Unpro-tected	Perm. Prot.	Exped. Prot.	Unpro-tected	
		Miles	Miles	Miles	Miles	$/ft	Miles	Miles	Miles	Miles	Miles	Miles	Miles
Residential Permanent Seasonal	6.0												
Commercial/ Industrial	18.8												
Transportation													
Utilities	1.9												
Agric/Forest & Undeveloped	17.1												
Other, Public Park & Open Space	26.0												
Total	69.8	1.7	7.3	17.4	43.4	62							

Reported non-residential damage conditions were balanced with 13 of 27 respondents (48 percent) suffering from erosion, and the remaining 14 (52 percent) confronted by flooding.

Inundation damage was most prevalent in the St. Louis River estuary, the Duluth Harbor, and along the bayside of Minnesota Point. All three of these areas are protected to a degree from extreme wave attack by Minnesota Point and Wisconsin Point.

Interviews conducted with some non-residential parcel owners revealed that flooding damages are sustained year-round, but particularly during the high water cycle in late summer and early fall, when severe northeasterly storms (with tilting of the lake body toward the Duluth area) cause most of the flooding and erosion problems. Several parcel owners stated that northeasterly storms cause the majority of flooding events and that if lake levels are raised an additional 6 to 12 inches, total property and business losses would result.

The bayside area of Minnesota Point is confronted with high risk of flooding due to its natural low lying relief. Residential flooding has been experienced along the entire bayside shoreline. Problems cited include flooded basements, foundation crackage and seepage, "spongy" lawns and mud bogs, and undermining of docks and boat houses. The entire stretch of residential frontages is included. Storm induced conditions from northeast and southeast were identified as the most prevelant cause of damages. Flooding is also being experienced by non-residential properties on the bayside or harbor near the Canal area and along the lakeside north of the Aerial Bridge toward Michigan Street. The city-owned Canal Park area is frequently inundated when northeasterly storm conditions occur. Serious erosion conditions have prevailed south of the Aerial Bridge Canal (groin) which has eroded beach area from the canal to 12th Avenue (lakeside).

Some of Duluth's finest homes are found along the bluffs in the northeastern section of the county. The non-erodible high-bluffs and non-erodible low-bluffs are not subject to flooding of any consequence. Few homes were severely inundated; however, basement seepage and high ground water levels caused some damages to residences. The only reported non-residential flood damage was experienced in the Lester Park area and was attributed to storm activity.

It is estimated that 463,000 square feet of beach area were lost due to high lake levels during the two-year time period. The "red clay" soil conditions found primarily beyond the Lester River (northeast) are very susceptible to erosion processes. Bank undermining, slumping, and other soil erosion processes, produced by surficial run-off and wave attack, severely erode the clay banks of the area. The volume of bluff material eroded during the two-year period is estimated to be 16.5 million cubic feet (see Table 4).

TABLE 4 :
PHYSICAL EROSION LOSSES

ST. LOUIS COUNTY, MINNESOTA

Labor Day 1972-
Labor Day 1974

	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	Number of Residences Located Within feet of edge of bluff					
			0-25	26-50	51-75	76-100	101-150	151-200
Actual Reported Projection for Entire Co.	463	16,140	27	26	18	16	6	15

TABLE 5 :
SUMMARY OF FLOOD AND EROSION DAMAGES (actual reported) ST. LOUIS COUNTY, MINNESOTA

Labor Day 1972-
Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	189	67	81	7	0	0	34	17	0	17	0
Commercial/ Industrial	392	283	8	37	20	36	8	49	2	32	15
Transportation											
Utilities	334	294	0	40	0	0	0	10	0	10	0
Agriculture											
Other											
Total	915	644	89	84	20	36	42	76	2	59	15
Erosion Damages											
Residential	233	28	151	5	0	0	49	90	0	90	0
Commercial/ Industrial	25	11	8	0	0	6	0	94	0	77	17
Transportation											
Agriculture											
Other											
Total	258	39	159	5	0	6	49	184	0	167	17
TOTAL Flood and Erosion	1,173	683	248	89	20	42	91	260	2	226	32

TABLE 6 : ST. LOUIS COUNTY, MINNESOTA Labor Day 1972-
SUMMARY OF FLOOD AND EROSION DAMAGES (projection for entire shoreline) 1/ Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	298	110	123	12	0	0	53	25	0	25	0
Commercial/ Industrial	392	283	8	37	20	36	8	49	2	32	15
Transportation											
Utilities	334	294	0	40	0	0	0	10	0	10	0
Agriculture											
Other											
Total	1,024	687	131	89	20	36	61	84	2	67	15
Erosion Damages											
Residential	321	38	210	7	0	0	66	135	0	135	0
Commercial/ Industrial	25	11	8	0	0	6	0	94	0	77	17
Transportation											
Agriculture											
Other											
Total	346	49	218	7	0	6	66	229	0	212	17
TOTAL Flood and Erosion	1,370	736	349	96	20	42	127	313	2	279	32

1/ Based on 67 percent response.

3. Flood and Erosion Damages

Reported flooding damage occurring from Labor Day 1972 to Labor Day 1974 amounted to $915,400. The largest damages were to grounds, landscaping, and trees, and damage to structures and contents. Non-residential flood damages were more severe than that experienced by residential parcels.

Erosion is the major cause of residential property damage along the St. Louis County shoreland. Erosion processes are responsible for bank recession and destruction of shore protective structures, and contribute large sediment loads to Lake Superior. Erosion damages were reported by 120 of 231 respondents for the two-year study period. Residential losses were largely a result of damage to grounds and improvements and protective structures.

Non-residential property owners did not incur large erosion damages compared to flooding damages. Flood and erosion damages are summarized in Tables 5 and 6.

B. Wisconsin

1. Douglas County

a. Physical Description

The shoreline of Douglas County begins beneath the high bridge to Duluth (Blatnik Bridge) and continues south and east past the Superior Harbor area to the Douglas-Bayfield County line. The distance from the northwestern tip of Wisconsin Point to the eastern boundary of Douglas County is approximately 25 miles. The Superior Harbor area, protected from the open lake by Wisconsin and Minnesota Points, contains another 18 miles of shoreline if all the numerous slips and entry ways are included. Figure 3 is a map of Douglas County.

The City of Superior, Wisconsin, lies at the western edge of the county at the Wisconsin-Minnesota state line. From that point eastward to Dutchman Creek, the shoreline consists of an erodible low plain interrupted only by Wisconsin Point, a sand spit. From Dutchman Creek eastward to the Brule River, a high-erodible bluff extends along the entire shoreline. East of the Brule River, a low-erodible bluff extends to the Douglas-Bayfield County line.

The reach of shoreline from the Blatnik Bridge to the base of Wisconsin Point includes Superior Harbor and Superior and Allouez Bays. Industrial development in the harbor is located along the southwest shore of Superior Bay and is constructed on a well-armored low plain consisting in part of artificial fill. The entire shoreline in this portion of the bay is stable and well fortified. To

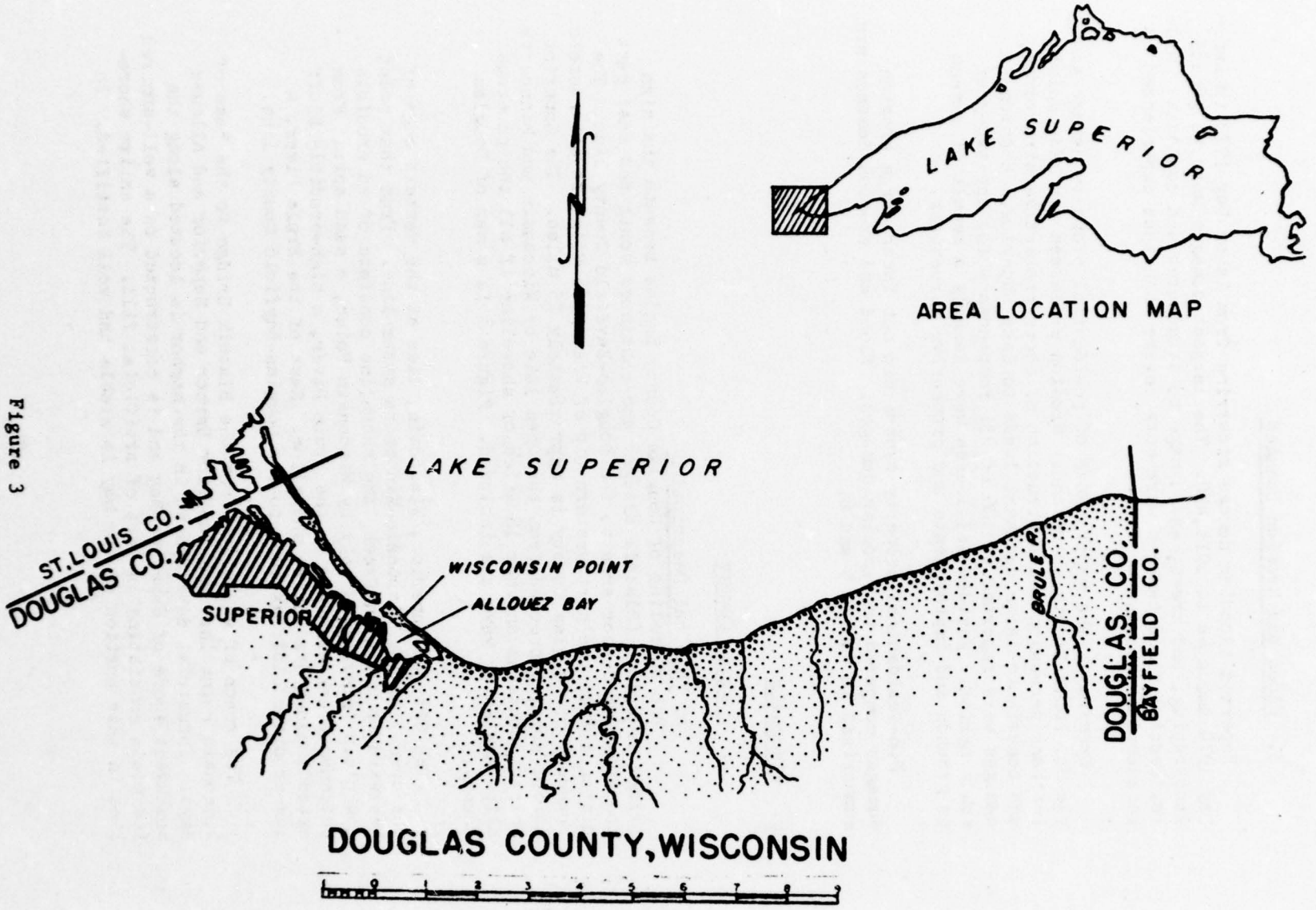

LAKE SUPERIOR
AREA LOCATION MAP
LAKE SUPERIOR
ST. LOUIS CO.
DOUGLAS CO.
SUPERIOR
WISCONSIN POINT
ALLOUEZ BAY
BRULE R.
DOUGLAS CO.
BAYFIELD CO.
DOUGLAS COUNTY, WISCONSIN

Figure 3

TABLE 7 :
SUMMARY OF GREAT LAKES SHORELINE USE, OWNERSHIP, VALUE & PROBLEM IDENTIFICATION

DOUGLAS COUNTY, WISCONSIN

Labor Day 1972-
Labor Day 1974

Shoreland Use	Miles Shoreland	Ownership				Aver. Assess. Value/front Foot	Problem Identification						Not subject to Erosion or Flood Damages
							Subject to Erosion			Subject to Flooding			
		Federal	State	Local	Priv.		Permanent Protection	Expedient Protection	Unprotected	Perm. Prot.	Exped. Prot.	Unprotected	
		Miles	Miles	Miles	Miles	$/ft	Miles	Miles	Miles	Miles	Miles	Miles	Miles
Residential Permanent Seasonal	0												
Commercial/ Industrial	5.1				5.1		3.2	1.7	0.2				
Transportation	0												
Utilities	0												
Agric/Forest & Undeveloped	25.6		5.3	6.3	14.0				22.2				
Other, Public Park & Open Space	5.0	0.4		4.6									
Total	35.7	0.4	5.3	10.9	19.1		3.2	1.7	22.4	0	0	0	8.4

TABLE 8:
PHYSICAL EROSION LOSSES

DOUGLAS COUNTY, WISCONSIN

Labor Day 1972-
Labor Day 1974

	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	Number of Residences Located Within feet of edge of bluff					
			0-25 1/	26-50	51-75	76-100	101-150	151-200
Actual Reported	2,280	45,261	1	0	0	0	0	8
Projection for Entire Co.	5,781	114,622						

1/ two residences destroyed.

TABLE 9 :
SUMMARY OF FLOOD AND EROSION DAMAGES (actual reported) DOUGLAS COUNTY, WISCONSIN

Labor Day 1972-
Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential											
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total											
Erosion Damages											
Residential	131	16	29	0	0	10	76	9	0	9	0
Commercial/ Industrial	39	39	0	0	0	0	0	1,422	1,400	10	12
Transportation											
Agriculture											
Other											
Total	170	55	29	0	0	10	76	1,431	1,400	19	12
TOTAL Flood and Erosion	170	55	29	0	0	10	76	1,431	1,400	19	12

TABLE 10 : DOUGLAS COUNTY, WISCONSIN Labor Day 1972-
SUMMARY OF FLOOD AND EROSION DAMAGES (projected for entire shoreline) 1/ Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential											
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total											
Erosion Damages											
Residential	213	26	47	0	0	16	124	15	0	15	0
Commercial/ Industrial	39	39	0	0	0	0	0	1,422	1,400	10	12
Transportation											
Agriculture											
Other											
Total	252	65	47	0	0	16	124	1,437	1,400	25	12
TOTAL Flood and Erosion	252	65	47	0	0	16	124	1,437	1,400	25	12

1/ Based on 61.4 percent residential response.

the southeast, in Allouez Bay, is an unimproved area of swampy lowlands and a few small islands surrounded by water generally less than six feet in depth. The entire harbor area is well sheltered from the open lake.

Wisconsin Point is a natural spit approximately 2.3 miles in length. It offers considerable protection to the Allouez Bay area and is classified as a low sand dune Reach, less than 30 feet in height. The Reach is an undeveloped recreational area, has no inhabitants except for summertime use of the University of Wisconsin -Superior Field Station at its terminus. The land is owned by the City of Superior and is an outstanding example of dune and beach sand accumulation. An erodible low plain wetland area, approximately 0.8 miles in length, is located just east of Wisconsin Point. For a distance of approximately 17 miles eastward it is a fairly straight stretch of shoreline. It serves as the terminus for a number of northward-flowing streams such as the Brule, Amnicon, Middle and Poplar Rivers. The entire 17 miles is an erodible high bluff. Lying at the foot of the bluff is an intermittent beach ranging in width from zero to 40 feet in width. A similar area of low bluffs extends the remaining four miles to the County line. See Table 7 for a description of shoreland ownership and use.

b. Nature and Extent of Physical Losses

Reported beach area lost and bluff volume eroded is presented in Table 8. Shown also are projections accounting for non-respondents properties for the entire county shoreline.

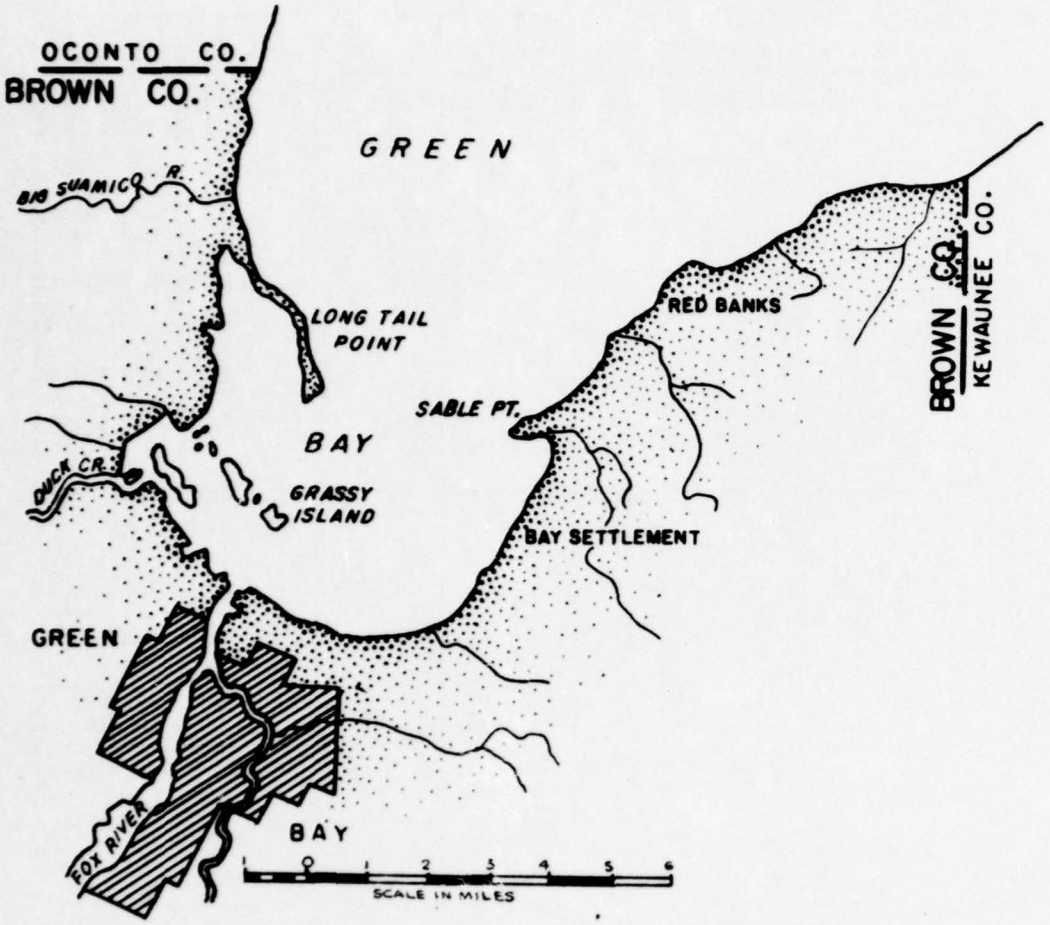
c. Flood and Erosion Damages

It was determined that all damages in Douglas County resulting from high water levels could be attributed to erosion rather than flooding. Accordingly, Table 9 presents reported actual erosion damages and Table 10 displays projected values for the entire county shoreline.

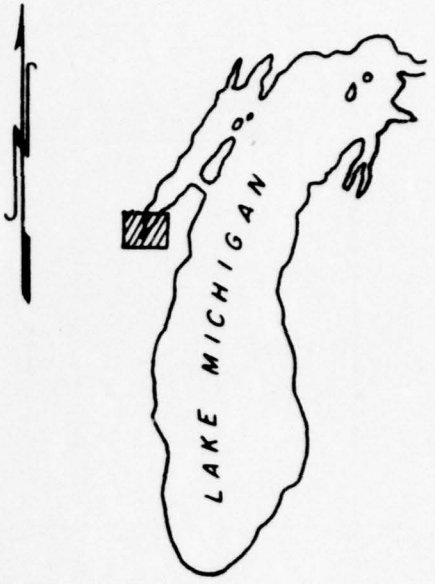
2. Brown County

a. Physical Description

The Brown County shoreline on Lake Michigan is approximately 41 miles in length and borders the southern end of the Green Bay waters. At the approximate center of the county's shoreline is the City of Green Bay where the Fox River enters Green Bay. From the Oconto-Brown County line around the head of Green Bay to Bay Settlement, there are no bluffs and the shoreline is a gently sloping plain or marshland. From Bay Settlement northeast to Red Banks the shoreland is moderate to high bluffs of glacial till and bedrock interrupted by occasional low-lying bluffs. From Red Banks three miles to the Kewaunee County line the shoreline is characterized by a smooth outline and steep bluffs. These areas are prone to water-wave erosion. See map, next page. Shoreline use and ownership is described in Table 11.



BROWN COUNTY, WISCONSIN



AREA LOCATION MAP

Figure 4

TABLE 11 :
SUMMARY OF GREAT LAKES SHORELINE USE, OWNERSHIP, VALUE & PROBLEM IDENTIFICATION

BROWN COUNTY WISCONSIN

Labor Day 1972-
Labor Day 1974

Shoreland Use	Miles Shoreland	Ownership				Aver. Assess. Value/front Foot	Problem Identification						Not subject to Erosion or Flood Damages
							Subject to Erosion			Subject to Flooding			
		Federal	State	Local	Priv.		Permanent Protection	Expedient Protection	Unprotected	Perm. Prot.	Exped. Prot.	Unprotected	
		Miles	Miles	Miles	Miles	$/ft	Miles	Miles	Miles	Miles	Miles	Miles	Miles
Residential Permanent Seasonal													
Commercial/ Industrial	6.14												
Transportation													
Utilities													
Agric/Forest & Undeveloped													
Other, Public Park & Open Space													
Total	41.0												

TABLE 12:
PHYSICAL EROSION LOSSES

BROWN COUNTY, WISCONSIN

Labor Day 1972-
Labor Day 1974

	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	Number of Residences Located Within feet of edge of bluff					
			0-25	26-50	51-75	76-100	101-150	151-200
Actual Reported	129	10,580						
Projection for Entire Co.	1,506	32,030	14	6	6	1	3	6

TABLE 13 :
SUMMARY OF FLOOD AND EROSION DAMAGES (actual reported) BROWN COUNTY, WISCONSIN

Labor Day 1972-
Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	2,973										
Commercial/ Industrial	1,055										
Transportation											
Utilities											
Agriculture											
Other	160										
Total	4,188										
Erosion Damages											
Residential	1,326	707	374	64	0	10	171	520	0	520	0
Commercial/ Industrial	809	148	608	27	0	25	1	158	8	150	0
Transportation											
Agriculture											
Other	0	0	0	0	0	0	0	864 1/	0	864 1/	0
Total	2,135	855	982	91	0	35	172	1,542	8	1,534	0
TOTAL Flood and Erosion	6,323	855	982	91	0	35	172	1,542	8	1,534	0

1/ Operation Foresight contract

TABLE 14 :
SUMMARY OF FLOOD AND EROSION DAMAGES (projected for entire shoreline) 1/

BROWN COUNTY, WISCONSIN

Labor Day 1972-
Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	2,973										
Commercial/ Industrial	1,055										
Transportation											
Utilities											
Agriculture											
Other	160										
Total	4,188										
Erosion Damages											
Residential	2,142	1,142	604	104	0	16	276	840	0	840	0
Commercial/ Industrial	809	148	608	27	0	25	1	158	8	150	0
Transportation											
Agriculture											
Other	0	0	0	0	0	0	0	864 2/	0	864 2/	0
Total	2,951	1,290	1,212	131	0	41	277	1,862	8	1,854	0
TOTAL Flood and Erosion	7,139	1,290	1,212	131	0	41	277	1,862	8	1,854	0

1/ Based on 62 percent residential response
2/ Operation Foresight contract.

b. Nature and Extent of Physical Losses

Amounts of beach are lost and bluff volume eroded, according to estimates made by property owners, are presented in Table 12. Projected estimates for the entire county shoreline are also displayed.

c. Flood and Erosion Damages

The U.S. Geological Survey's (Water Resources) Open-File Report on the 9-10 April 1973 flood in the area of Green Bay, Wisconsin, provided estimates of flood damages for Brown County. The April 1973 flood is the only flood recorded from May 1972 through Labor Day 1974. This study identifies the flood-prone zone as the area from Duck Creek (just west of the Fox River) to Point au Sable (the first major promontory east of the Fox River).

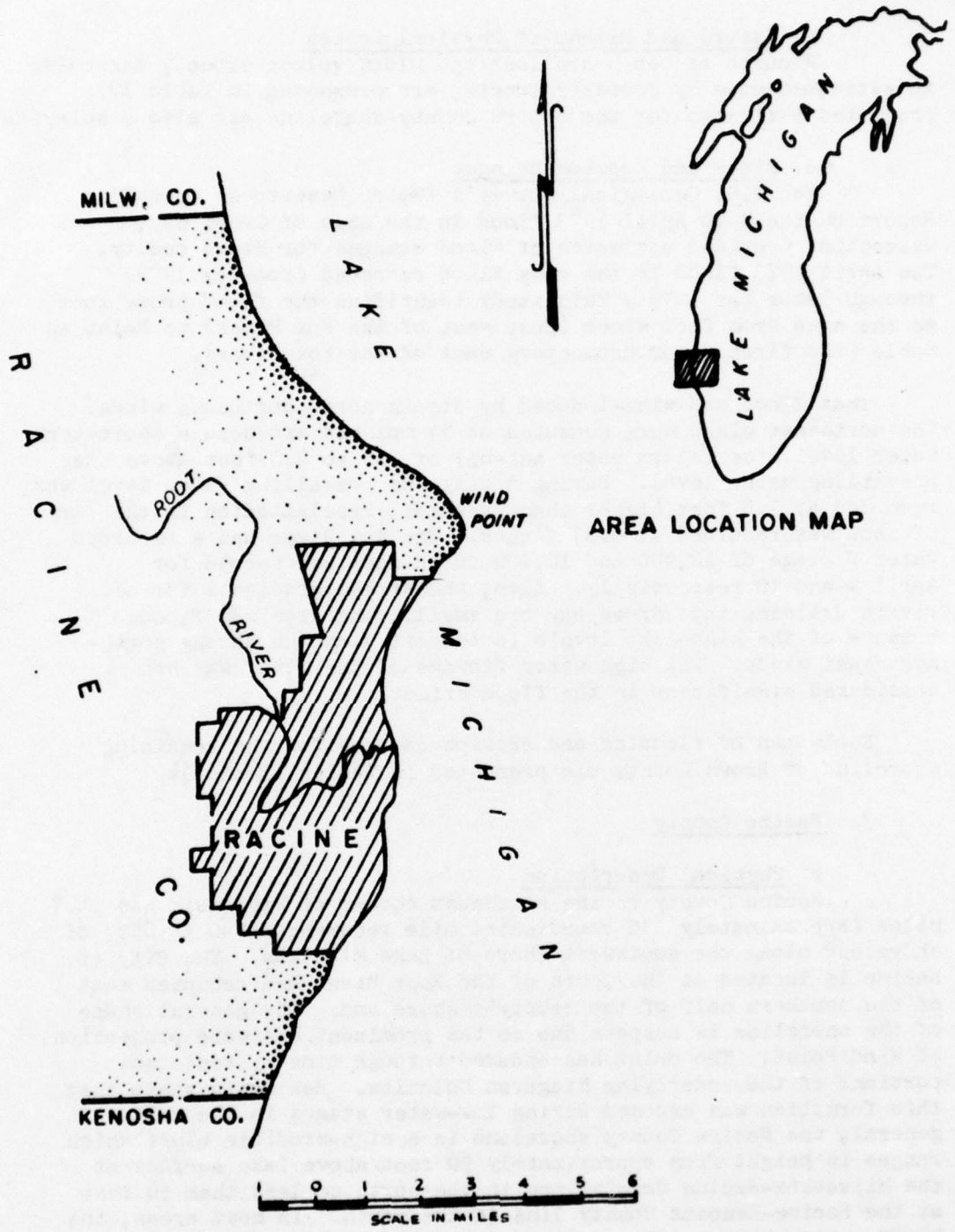
That flood was wind-induced by strong north-northeast winds. The northeast winds were measured at 54 mph and produced a short-term water level rise (storm water set-up) of 3.7 to 4.0 feet above the prevailing water level. During April, the prevailing water level was recorded at 1.8 feet higher than average. Precipitation in the form of snow was recorded at 0.37 inches. The Fox River had a recorded water flowage of 12,400 and 12,100 cubic feet per second for April 9 and 10 respectively. Also, the stream gradients for all rivers draining into Green Bay are small. The area was flooded because of the high lake levels in concert with the strong north-northeast winds. The high water flowage of the river was not considered significant in the flood effect.

Estimates of flooding and erosion damages for the remaining shoreline of Brown County are presented in Tables 13 and 14.

3. Racine County

a. Physical Description

Racine County in the southeast corner of Wisconsin has 14.7 miles (approximately IJC coordinated mile references 640 to 655) of shoreland along the southwest shore of Lake Michigan. The City of Racine is located at the mouth of the Root River and occupies most of the southern half of the county's shoreland. The general shape of the shoreline is cuspate due to the prominent eastward projection of Wind Point. The point has endured through time by resistant portions of the underlying Niagaran Dolomite. Residents state that this formation was exposed during low-water stages in the past. In general, the Racine County shoreland is a high-erodible bluff which ranges in height from approximately 90 feet above lake surface at the Milwaukee-Racine County line in the north to less than 50 feet at the Racine-Kenosha County line in the south. In most areas, the bluff varies between 30 and 40 feet in height above Lake Michigan. In the vicinity of Wind Point there is 1.4 miles of low-erodible bluff shoreline less than 30 feet in height. See map, next page.



RACINE COUNTY, WISCONSIN

Figure 5

TABLE 15 :
SUMMARY OF GREAT LAKES SHORELINE USE, OWNERSHIP, VALUE & PROBLEM IDENTIFICATION

RACINE COUNTY WISCONSIN

Labor Day 1972-
Labor Day 1974

Shoreland Use	Miles Shore-land	Ownership				Aver. Assess. Value/front Foot	Problem Identification						Not subject to Erosion or Flood Damages
							Subject to Erosion			Subject to Flooding			
		Federal	State	Local	Priv.		Permanent Protection	Expedient Protection	Unpro-tected	Perm. Prot.	Exped. Prot.	Unpro-tected	
		Miles	Miles	Miles	Miles	$/ft	Miles	Miles	Miles	Miles	Miles	Miles	Miles
Residential Permanent Seasonal	6.7												
Commercial/ Industrial	0.8												
Transportation	0.3												
Utilities	1.0												
Agric/Forest & Undeveloped	0.6												
Other, Public Park & Open Space	5.3												
Total	14.7	0.3	0.1	5.4	8.9		6.7	3.0	5.1				

TABLE 16:
PHYSICAL EROSION LOSSES

RACINE COUNTY, WISCONSIN

Labor Day 1972-
Labor Day 1974

	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	Number of Residences Located Within feet of edge of bluff					
			1-25	26-50	51-75	76-100	101-150	151-200
Actual Reported	1,024	24,326						
Projection for Entire Co.	2,250	53,500	12	25	17	14	12	1

TABLE 17 :
SUMMARY OF FLOOD AND EROSION DAMAGES (actual reported) RACINE COUNTY, WISCONSIN

Labor Day 1972-
Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential											
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total											
Erosion Damages											
Residential	1,220	20	938	24	0	0	238	332	0	332	0
Commercial/ Industrial	93	30	61	1	0	1	0	0	0	0	0
Transportation	10	0	10	0	0	0	0	0	0	0	0
Utilities	261	188	13	11	0	0	49	0	0	0	0
Agriculture											
Other	76	17	44	15	0	0	0	1,576 1/	6 1/	1,570 1/	0
Total	1,660	255	1,066	51	0	1	287	1,908	6	1,902	0
TOTAL Flood and Erosion	1,660	255	1,066	51	0	1	287	1,908	6	1,902	0

1/ Nonresidential total

TABLE 18 : RACINE COUNTY, WISCONSIN Labor Day 1972-
SUMMARY OF FLOOD AND EROSION DAMAGES (projected for entire shoreline) 1/ Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential											
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total											
Erosion Damages											
Residential	2,140	35	1,646	42	0	0	417	582	0	582	0
Commercial/ Industrial	93	30	61	1	0	1	0	1,576 2/	6	2/ 1,570	2/ 0
Transportation	10	0	10	0	0	0	0	0	0	0	0
Utilties	261	188	13	11	0	0	49	0	0	0	0
Agriculture											
Other	76	17	44	15	0	0	0	0	0	0	0
Total	2,580	270	1,774	69	0	1	466	2,158	6	2,152	0
TOTAL Flood and Erosion	2,580	270	1,774	69	0	1	466	2,158	6	2,152	0

1/ Based on 57 percent residential response

2/ Nonresidential total

Much of Racine County shoreland (6.6 miles or 46 percent) is used for private residential purposes. The properties are concentrated in a six-mile section extending south from a point approximately two miles south of the Milwaukee-Racine County line, and along the southernmost two miles of Racine County shore. Shoreline use and ownership is shown in Table 15.

b. Nature and Extent of Physical Losses

The southernmost two-mile section of Racine County shoreland has the most critical erosion problems in the county. This section has the highest bluff recession rate, the least amount of permanent protection, and the highest number of residences within 25 feet of the bluff edge of any developed segment of the county's shoreland.

Severe problems also exist in the segment running from 0.3 miles to 2.8 miles south of the Milwaukee-Racine County line. As the area is undeveloped, the immediate impact of shore erosion on properties is not as great as it is along other sections of the county's shore. Finally, the shoreland segment extending south from mile 652 for 4,000 feet has serious erosion problems. Reported and projected beach area lost and bluff erosion is presented in Table 16.

c. Flooding and Erosion Damages

All of Racine County's shoreland properties along Lake Michigan suffered some damage during the study period Labor Day 1972 to Labor Day 1974. The damages were the combined result of particularly high lake levels and severe storms, especially during November 1972 and April 1973. Property owners who reported no damage either conisidered the loss to be too minor to report, or were unaware of the losses. Damages frequently varied considerably in extent and amount between adjacent properties.

Some residential property owners reported erosion damages. After on-site observations were made in the field, it was apparent that although some lands had been inundated and reported as flooding, the real cause of damage was the erosive effect of the waves on bluffs and structures located on the bluffs. Accordingly, all such reports of flooding were incorporated under erosion categories for this report. Actual damages reported and projected damages for the entire county shoreline are shown in Tables 17 and 18.

C. Michigan

1. Chippewa County

a. Physical Description

Chippewa County, located in the Upper Peninsula, is to the east of Luce County and to the north of Mackinac County. Figure 6

is a map of the study area in Chippewa County. Only that part of the Chippewa County shoreline which borders Lake Superior is included in this pilot study. The remaining portion of Chippewa County borders the St. Marys River. The eastern edge of the study area begins at Brush Point, located six miles west of Sault Ste. Marie, and continues westward for 87 miles.

The Chippewa County shoreline along Lake Superior from the Luce-Chippewa County line to Brush Point alternates between erodible plains and erodible low bluffs. With minor exceptions, the area extending from below Paradise, Michigan, to several miles west of the Naomikong Point is low, non-erodible bluff, as is a small stretch of shoreline from Salt Point westward to the Pendills Creek outlet. High risk erosion areas along this shoreline are located both west and south of Whitefish Point. Many homes are endangered in the Paradise area of Whitefish Bay, and scattered high risk erosion areas also exist along the south side of Chippewa County's shoreline.

Of the 92 percent of the Chippewa shoreline which is privately owned, residential properties are a large majority; 79 percent are for seasonal use only. Shoreline ownership and use are described in Table 19.

b. Nature and Extent of Physical Losses

The amount of beach area as well as volume of bluff reported lost in this area was substantial. The majority of dwellings in this county are located within 50 feet of the bluff edge and are therefore threatened by substantial erosion damage (see Table 20).

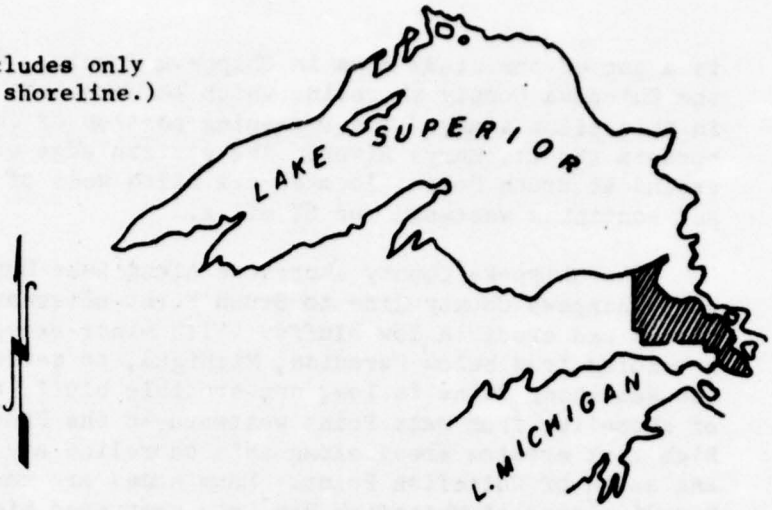
c. Flood and Erosion Damages

Respondents to the assessment from this county indicated the highest dollar damage due to flooding of the six Michigan counties surveyed. More than a quarter of a million dollars in damages were reported due to flooding problems. Major losses occurred to grounds and improvements, which accounted for almost 60 percent of the reported damages. Structure and contents losses and clean-up costs were substantial as well.

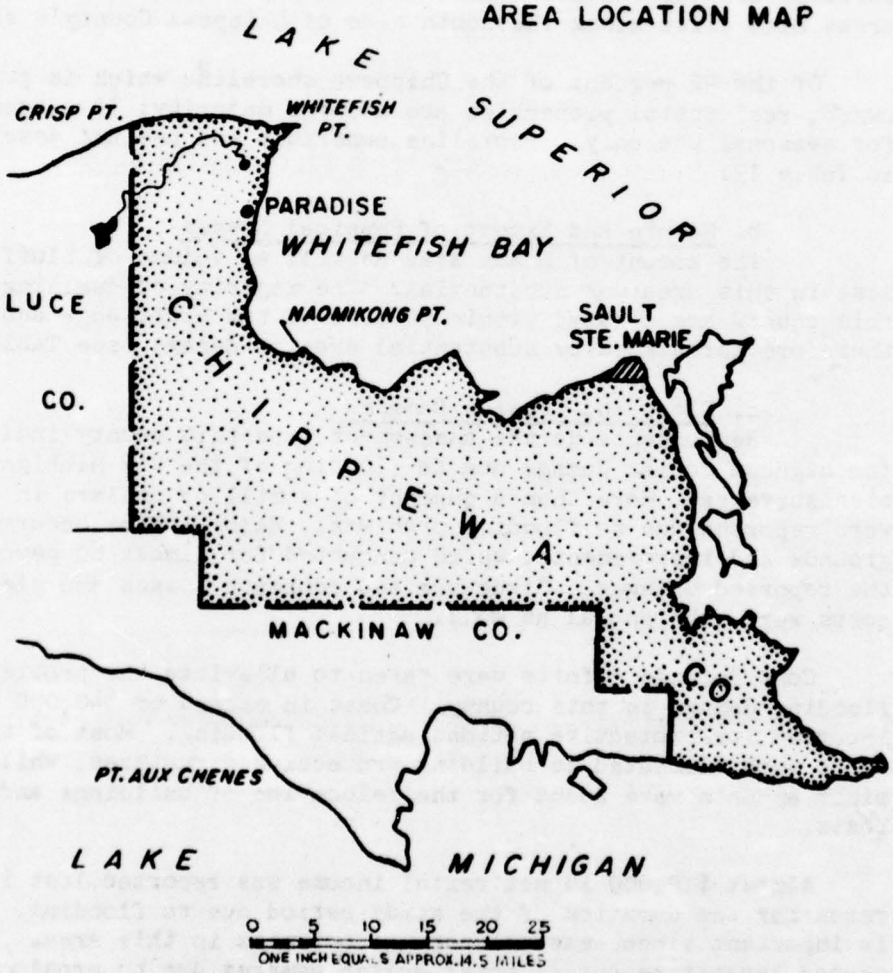
Considerable efforts were taken to alleviate the problem of flooding damage in this county. Costs in excess of $40,000 were incurred for protective actions against flooding. Most of the costs were allocated to building protective structures, while minor amounts were spent for the relocation of buildings and other costs.

Almost $12,000 in net rental income was reported lost in this reach for the duration of the study period due to flooding. This is important since seasonal use predominates in this area. The second largest amount of total dollar damages due to erosion in Michigan occurred to shoreline property in this county. Over

(The study area includes only the Lake Superior shoreline.)



AREA LOCATION MAP



CHIPPEWA COUNTY, MICHIGAN

Figure 6

TABLE 19 :
SUMMARY OF GREAT LAKES SHORELINE USE, OWNERSHIP, VALUE & PROBLEM IDENTIFICATION

CHIPPEWA COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

Shoreland Use	Miles Shoreland	Ownership				Aver. Assess. Value/front Foot	Problem Identification						Not subject to Erosion or Flood Damages
							Subject to Erosion			Subject to Flooding			
		Federal	State	Local	Priv.		Permanent Protection	Expedient Protection	Unprotected	Perm. Prot.	Exped. Prot.	Unprotected	
		Miles	Miles	Miles	Miles	$/ft	Miles	Miles	Miles	Miles	Miles	Miles	Miles
Residential Permanent Seasonal													
Commercial/ Industrial													
Transportation													
Utilities													
Agric/Forest & Undeveloped													
Other, Public Park & Open Space													
Total	78.8					55							

TABLE 20 :
PHYSICAL EROSION LOSSES

CHIPPEWA COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	Number of Residences Located Within feet of edge of bluff 0-25	26-50	51-75	76-100	-150	151-200
Actual Reported Projection for Entire Co.	9,600	49,100	99	122	47	29	14	10

$500,000 was reported as loss to grounds and improvements, while miscellaneous items sustained half that amount, as shown in Tables 21 and 22.

2. Schoolcraft County

a. Physical Description

Schoolcraft County is located along the northern shore of Lake Michigan in the Upper Peninsula. It is bordered by Alger County to the north, Delta County to the west, and Mackinac County to the east. Figure 7 is a map of Schoolcraft County. The shoreline extends for 49.8 miles. It is generally irregular and contains many small bays which are protected by natural jetties of rock points reaching out into the lake. Some stretches of shoreline consist of stone or gravel beaches with intermittent stretches of sand beach, especially in the innermost parts of the bays.

From the Schoolcraft-Mackinac County line, the shoreline of Schoolcraft County consists of a sheer rock wall for eight miles west to Goodreau's Harbor. From there, six miles to the west along the shoreline are low sand dunes. For the next 24 miles, to Point Aux Barques, the shoreline alternates between low plains of cobbles and low sand dunes, except for two areas of limestone outcroppings on either side of Dutch John's Point and between Thompson and Wiggins Point. From Point Aux Barques to Little Harbor, a distance of five miles, there are sand marshes over flat-lying limestone formations. From Little Harbor to the Schoolcraft-Delta County line, the shoreline is characterized by cobbles with an underlayer of bedrock.

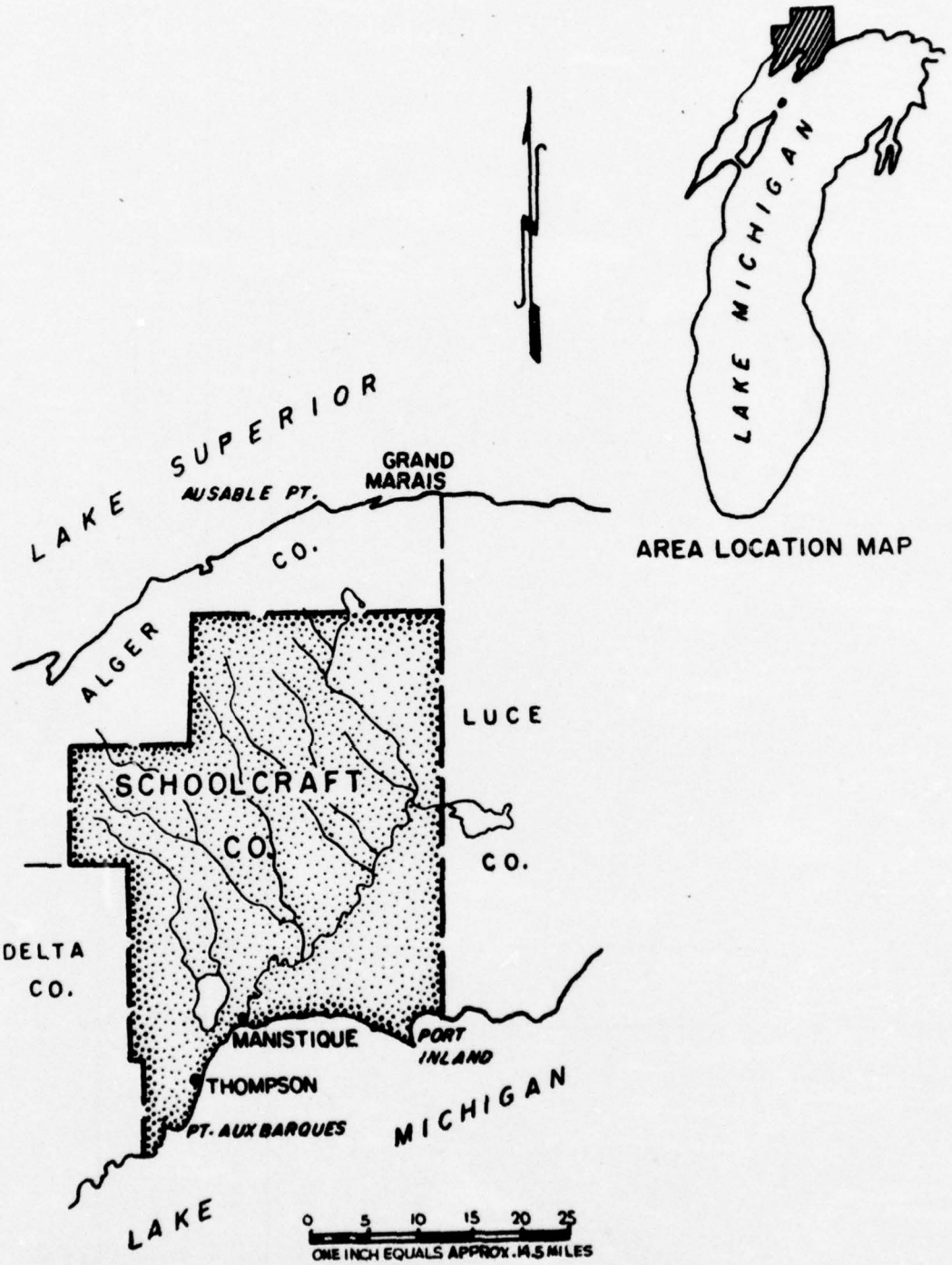
This shoreline area on Lake Michigan is generally not subject to critical erosion. Much of the shoreline is protected by outcropping limestone or by gravel and cobble beaches.

Manistique, the major city in Schoolcraft County, is built along the shores of the Indian River leading into Lake Michigan. It has a population of 4,875.

The residential lands in Schoolcraft County are primarily used seasonally. Of those respondents to the self-administered assessment who classified their property as either seasonal or permanent, 64 percent responded that they make seasonal use of the land. The only area where this is not true is Manistique, where all the properties were reported as permanent residences (see Table 23).

b. Nature and Extent of Physical Losses

Shoreline property owners within this county reported the smallest amount of erosion damage in the Michigan counties studied. See Table 24. The most damages were reported to grounds and improvements, while considerably less damages were identified as clean-up



SCHOOLCRAFT COUNTY, MICHIGAN

Figure 7

TABLE 21 :
SUMMARY OF FLOOD AND EROSION DAMAGES (actual reported) CHIPPEWA COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	269	29	145	8	0	12	75	44	4	38	2
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total	269	29	145	8	0	12	75	44	4	38	2
Erosion Damages											
Residential	836	31	502	45	+	16	242	433	7	418	8
Commercial/ Industrial	10	1	7	0	0	2	0	28	0	27	1
Transportation											
Agriculture											
Other											
Total	846	32	509	45	0	18	242	461	7	445	9
TOTAL Flood and Erosion	1,115	61	654	53	0	30	317	505	11	483	11

+ = positive value reported, less than $1,000

TABLE 22 : CHIPPEWA COUNTY, MICHIGAN

SUMMARY OF FLOOD AND EROSION DAMAGES (projected for entire shoreline) 1/

Labor Day 1972-
Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	427	46	230	12	0	19	120	73	6	64	3
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total	427	46	230	12	0	19	120	73	6	64	3
Erosion Damages											
Residential	1,329	50	798	71	+	26	384	719	12	694	13
Commercial/ Industrial	10	1	7	0	0	2	0	28	0	27	1
Transportation											
Agriculture											
Other											
Total	1,339	51	805	71	0	28	384	747	12	721	14
TOTAL Flood and Erosion	1,766	97	1,035	83	0	47	504	820	18	785	17

1/ Based on 65 percent response

+ = positive value reported, less than $1,000.

TABLE 23 :
SUMMARY OF GREAT LAKES SHORELINE USE, OWNERSHIP, VALUE & PROBLEM IDENTIFICATION

SCHOOLCRAFT COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

Shoreland Use	Miles Shoreland	Ownership				Aver. Assess. Value/front Foot	Problem Identification						Not subject to Erosion or Flood Damages
							Subject to Erosion			Subject to Flooding			
		Federal	State	Local	Priv.		Permanent Protection	Expedient Protection	Unprotected	Perm. Prot.	Exped. Prot.	Unprotected	
		Miles	Miles	Miles	Miles	$/ft	Miles	Miles	Miles	Miles	Miles	Miles	Miles
Residential Permanent Seasonal													
Commercial/ Industrial													
Transportation													
Utilities													
Agric/Forest & Undeveloped													
Other, Public Park & Open Space													
Total	49.8					50							

TABLE 24:
PHYSICAL EROSION LOSSES

SCHOOLCRAFT COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	Number of Residences Located Within feet of edge of bluff					
			0-25	26-50	51-75	76-100	101-150	151-200
Actual Reported Projection for Entire Co.	14,100	10,600	4	4	6	7	2	2

costs. Minor unspecified damage reported was a negligible amount of structural damage. There are only eight dwellings reported within 50 feet of the bluff edge throughout this entire county. The little erosion damage reported is consistent with the physical characteristics of the shoreline.

c. Flood and Erosion Damages

Much of the shoreline is protected by gravel and cobble beaches or by outcrops of limestone; property owners reported minimal flooding damages; flooding damages did not exceed $5,000 for the entire county. There were also no reports of protective actions. The 100-year open-coast flood level map confirms that flooding is not a severe problem in this county. The only damage category with a substantial damage is residential erosion of grounds and improvements (see Tables 25 and 26).

3. Muskegon County

a. Physical Description

Muskegon County, located in the Lower Peninsula, is bordered by Oceana County on the north, Ottawa County on the south, and Kent County on the east. Lake Michigan forms the county's western border which stretches for 26.9 miles. Figure 8 is a map of Muskegon County.

The Muskegon County Lake Michigan shoreline from the Oceana-Muskegon County line to a point nine miles south consists of high sand dune and occasional low clay bluff. In the Michilinda Beach area bluffs are sand over clay. Dunes sometimes range up to 200 feet high and are composed of medium grain sand.

Then south to Muskegon State Park the shoreline is sand bluff in part stabilized by extensive vegetation. The bluff is as much as 120 feet above the lake level, while a sand beach 10 to 30 feet wide exists below the bluff.

The shoreline from Muskegon State Park to the Muskegon-Ottowa County line consists of gently sloping sand beach, 10 to 60 feet wide, and backed by sand bluffs 30 feet high and high sand dunes rising up to 250 feet above lake level.

Government lands occupy three percent of the shoreline. The City of Muskegon is the largest city in Muskegon County and is located on Muskegon Lake. The city has a population of approximately 43,000 people, with an additional 19,000 people in nearby areas. Of residential properties in Muskegon County, more than half (54 percent) are used seasonally. Shoreland ownership and use is shown in Table 27.

TABLE 25 :
SUMMARY OF FLOOD AND EROSION DAMAGES (actual reported) SCHOOLCRAFT COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

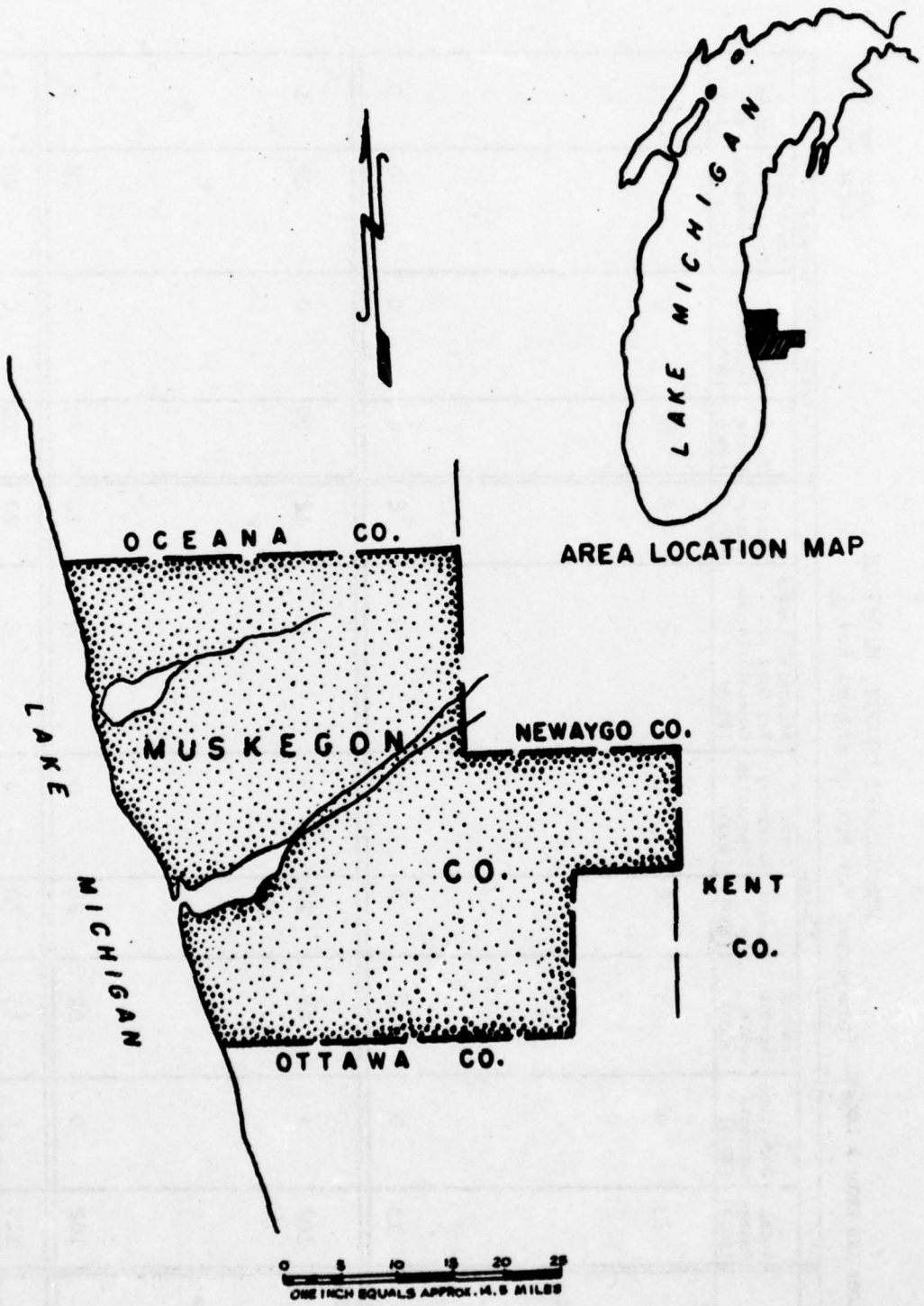
	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	5	0	1	1	0	0	3	0	0	0	0
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total	5	0	1	1	0	0	3	0	0	0	0
Erosion Damages											
Residential	36	+	22	10	0	0	4	4	0	4	0
Commercial/ Industrial											
Transportation											
Agriculture											
Other											
Total	36	0	22	10	0	0	4	4	0	4	0
TOTAL Flood and Erosion	41	0	23	11	0	0	7	4	0	4	0

+ = positive value reported, less than $1,000

TABLE 26: SCHOOLCRAFT COUNTY, MICHIGAN Labor Day 1972-
SUMMARY OF FLOOD AND EROSION DAMAGES (projected for entire shoreline) 1/ Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	13	0	3	2	0	0	8	0	0	0	0
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total	13	0	3	2	0	0	8	0	0	0	0
Erosion Damages											
Residential	102	+	62	28	0	0	12	20	0	20	0
Commercial/ Industrial											
Transportation											
Agriculture											
Other											
Total	102	0	62	28	0	0	12	20	0	20	0
TOTAL Flood and Erosion	115	0	65	30	0	0	20	20	0	20	0

1/ Based on 41 percent response.
+ = positive value reported, less than $1,000.



MUSKEGON COUNTY, MICHIGAN

Figure 8

TABLE 27:
SUMMARY OF GREAT LAKES SHORELINE USE, OWNERSHIP, VALUE & PROBLEM IDENTIFICATION

MUSKEGON COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

Shoreland Use	Miles Shore-land	Ownership				Aver. Assess. Value/front Foot	Problem Identification						Not subject to Erosion or Flood Damages
							Subject to Erosion			Subject to Flooding			
		Federal	State	Local	Priv.		Permanent Protection	Expedient Protection	Unprotected	Perm. Prot.	Exped. Prot.	Unprotected	
		Miles	Miles	Miles	Miles	$/ft	Miles	Miles	Miles	Miles	Miles	Miles	Miles
Residential Permanent													
Seasonal													
Commercial/ Industrial													
Transportation													
Utilities													
Agric/Forest & Undeveloped													
Other, Public Park & Open Space													
Total	26.9					180							

b. Nature and Extent of Physical Losses

This area reported the second largest quantity of beach area lost, totalling nearly 2,814,000 square feet during the study period. The estimated volume of bluff lost was the highest of all Michigan pilot study counties, nearly 250 million cubic feet. The majority of residences are located within 50 feet of the bluff edge, thus the high recession rate poses a severe threat to property owners (see Table 28).

c. Flood and Erosion Damages

Economic losses due to high lake levels are significantly greater in Muskegon County than in other Michigan counties included in the study. Extensive monetary losses were reported for damages to grounds and improvements, with substantial additional losses due to damages to structures and their contents. Clean-up and miscellaneous damages have also been reported, constituting additional costs to property owners, of approximately $145,000. Minimal losses were listed for damage to structures and contents, clean-up costs, and loss of rental income. Only one area reported action taken to protect property from flooding. The action was in the form of building protective structures and amounted to $4,900. Erosion damages and expenditures for protective structures in Muskegon County were substantial; they are shown in Tables 29 and 30.

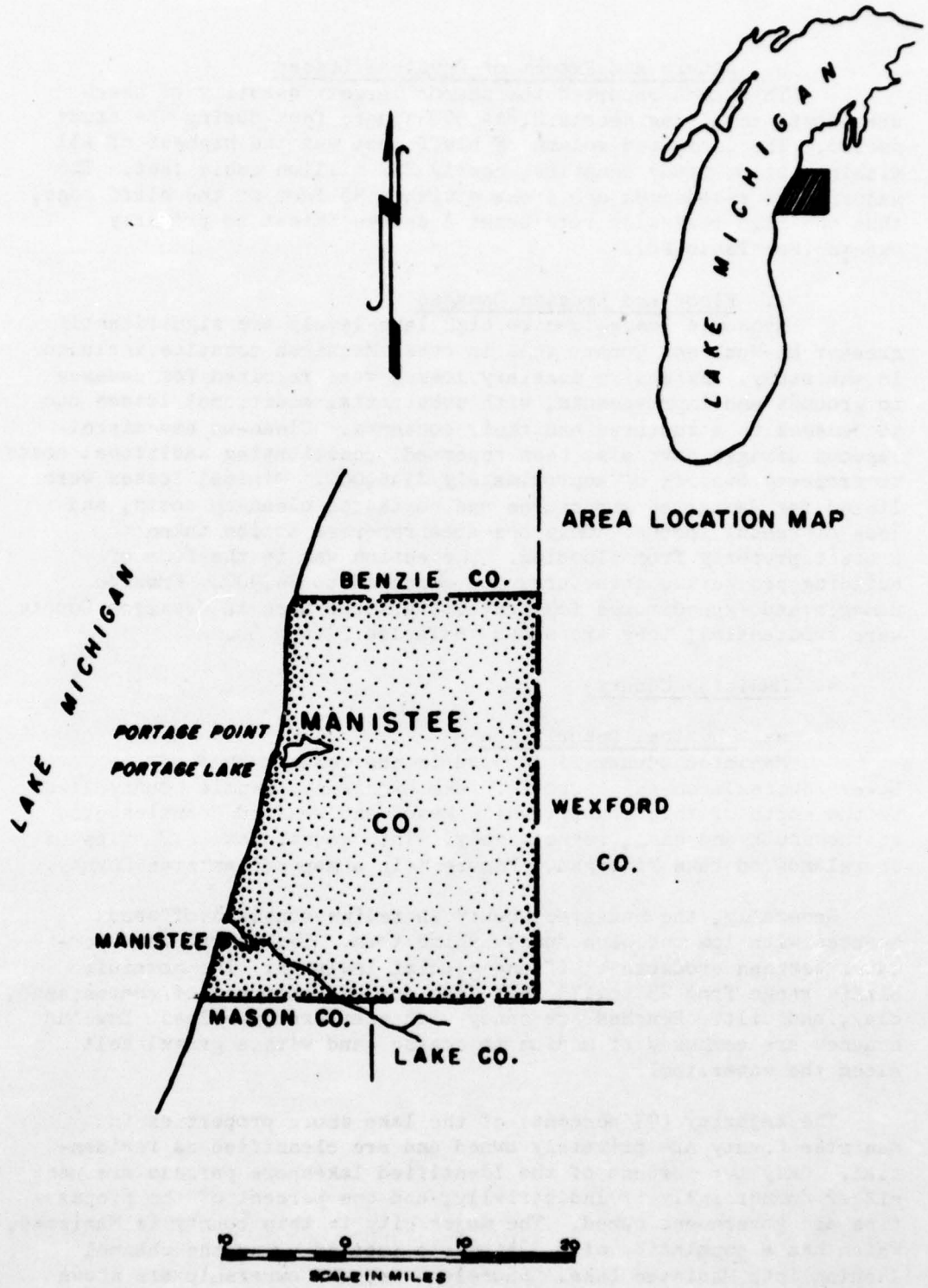
4. Manistee County

a. Physical Description

Manistee County is located in the western half of the Lower Peninsula on the shores of Lake Michigan. Benzie County lies to the north of this county, while Mason and Wexford Counties are to the south and east, respectively. This county has 26.2 miles of shorelands on Lake Michigan. Figure 9 is a map of Manistee County.

Generally, the Manistee County shoreline consists of sand beaches with low and high dunes behind them. The shoretype alternates between erodible bluff and glacial lowlands. The morainic bluffs range from 25 to 175 feet high and are composed of coarse sand, clay, and silt. Beaches are sandy with scattered pebbles. Lowland beaches are composed of medium to coarse sand with a gravel belt along the waterline.

The majority (97 percent) of the lake shore properties in Manistee County are privately owned and are classified as residential. Only two percent of the identified lakeshore parcels are used either commercially or industrially, and one percent of the properties are government owned. The major city in this county is Manistee, which has a population of 8,324 and is located along the channel leading into Manistee Lake. Shoreland use and ownership are shown in Table 31.



MANISTEE COUNTY, MICHIGAN

Figure 9

TABLE 28:
PHYSICAL EROSION LOSSES

MUSKEGON COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	Number of Residences Located Within feet of edge of bluff					
			0-25	26-50	51-75	76-100	101-150	151-200
Actual Reported Projection for Entire Co.	13,700	224,510	51	54	31	20	12	9

TABLE 29:
SUMMARY OF FLOOD AND EROSION DAMAGES (actual reported) MUSKEGON COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	148	+	53	2	0	2	91	5	0	5	0
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total	148	0	53	2	0	2	91	5	0	5	0
Erosion Damages											
Residential	1,174	77	671	79	0	32	315	477	52	415	10
Commercial/ Industrial	17	3	10	0	0	4	0	8	0	+	8
Transportation											
Agriculture											
Other											
Total	1,191	80	681	79	0	36	315	485	52	415	18
TOTAL Flood and Erosion	1,339	80	734	81	0	38	406	490	52	420	18

+ = positive value recorded, less than $1,000.

TABLE 30: MUSKEGON COUNTY, MICHIGAN Labor Day 1972-Labor Day 1974

SUMMARY OF FLOOD AND EROSION DAMAGES (projected for entire shoreland) 1/

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	253	+	91	3	0	3	156	14	0	14	0
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total	253	0	91	3	0	3	156	14	0	14	0
Erosion Damages											
Residential	2,001	131	1,146	134	0	55	535	1,332	145	1,159	28
Commercial/ Industrial	17	3	10	0	0	4	0	8	0	+	8
Transportation											
Agriculture											
Other											
Total	2,018	134	1,156	134	0	59	535	1,340	145	1,159	36
TOTAL Flood and Erosion	2,271	134	1,247	137	0	62	691	1,354	145	1,173	36

1/ Based on 63 percent response.

+ = positive value reported, less than $1,000

TABLE 31 :
SUMMARY OF GREAT LAKES SHORELINE USE, OWNERSHIP, VALUE & PROBLEM IDENTIFICATION

MANISTEE COUNTY MICHIGAN

Labor Day 1972-
Labor Day 1974

Shoreland Use	Miles Shore-land	Ownership				Aver. Assess. Value/front Foot	Problem Identification						Not subject to Erosion or Flood Damages
							Subject to Erosion			Subject to Flooding			
		Federal	State	Local	Priv.		Permanent Protection	Expedient Protection	Unpro-tected	Perm. Prot.	Exped. Prot.	Unpro-tected	
		Miles	Miles	Miles	Miles	$/ft	Miles	Miles	Miles	Miles	Miles	Miles	Miles
Residential Permanent Seasonal													
Commercial/ Industrial													
Transportation													
Utilities													
Agric/Forest & Undeveloped													
Other, Public Park & Open Space													
Total	26.2					105							

b. Nature and Extent of Physical Losses

This county reported substantial losses of beach area. The reported volume of bluff lost was also substantial, nearly 96 million cubic feet. There are 81 residences reported to be within 50 feet of the bluff edge and threatened by erosion. Areas in Manistee County experiencing severe erosion include the shoreline at the southern limit of the county, the shoreline immediately south of Portage Lake, the shoreline immediately south of Arcadia Lake, and a shoreline in the vicinity of the golf course south of Manistee.

Considerable efforts were made to provide protection against shoreline erosion. Property owners incurred the greatest costs in the construction of protective structures. Relocation costs were also substantial and were the second largest reported by the Michigan counties. Miscellaneous protective measures involved minor costs, and there were no emergency evacuations undertaken. Table 32 lists the physical losses.

c. Flood and Erosion Damages

Flooding damages reported in Manistee County totalled about $106,000. About 80 percent of this figure was identified as damages to grounds and improvements. The remaining amounts were divided among the other three categories. Erosion damages were more severe, totalling $777,000, consisting primarily of damages to grounds and improvements (see Tables 33 and 34).

5. Alcona County

a. Physical Description

Alcona County is bordered by Alpena County to the north, Iosco County to the south, and Oscoda County to the west. Its eastern border, formed by Lake Huron, is 26.7 miles long. Figure 10 is a map of Alcona County.

Generally, the Alcona County shoreline is erodible plain, and includes a five-mile marshy stretch in the middle of the county. From the northern county border (Alpena-Alcona County line) to Harrisville, the shoreland is mainly stone and boulder, with high bank beaches extending back into the hills. From there to the Alcona-Iosco County line, the shoreline consists of sandy beaches, usually low, with some high bluffs directly behind. Three areas in Alcona County have been identified as high risk erosion areas, which total about three miles in length. Most of the County's shoreline is erodible.

Land used for residential purposes accounts for 97 percent of the lakeshore properties in Alcona County. There were no large industries identified in Alcona County. The residential properties in the county are primarily used seasonally. This use pattern was

TABLE 32:
PHYSICAL EROSION LOSSES

MANISTEE COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

	Amount of Beach Area Lost	Amount of Bluff Volume Lost	Number of Residences Located Within feet of edge of bluff					
	(000 sq. ft.)	(000 cu. ft.)	0-25	26-50	51-75	76-100	101-150	151-200
Actual Reported Projection for Entire Co.	7,300	99,600	37	44	15	8	7	0

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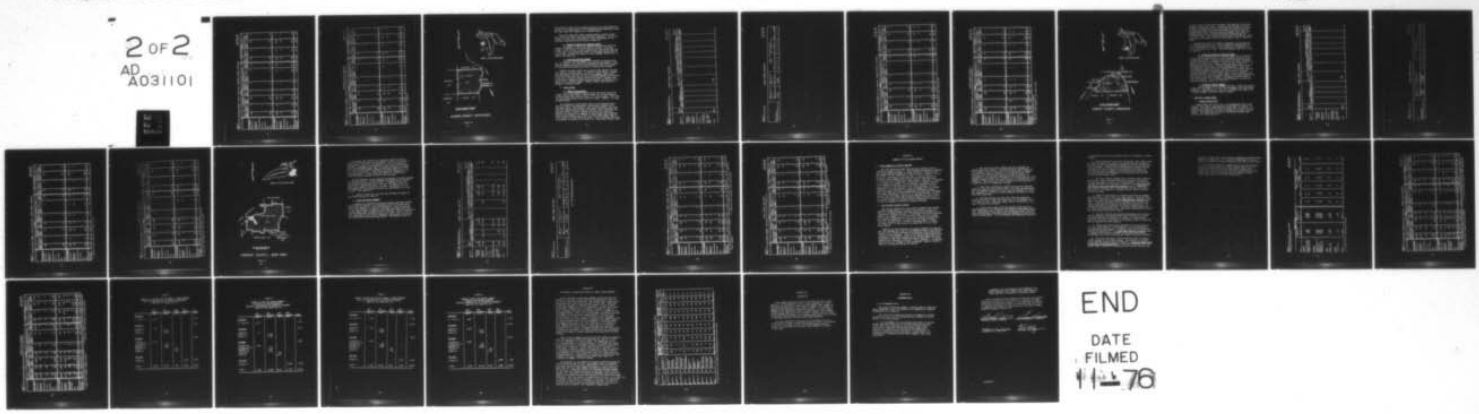

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TABLE 33 :
SUMMARY OF FLOOD AND EROSION DAMAGES (actual reported) MANISTEE COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

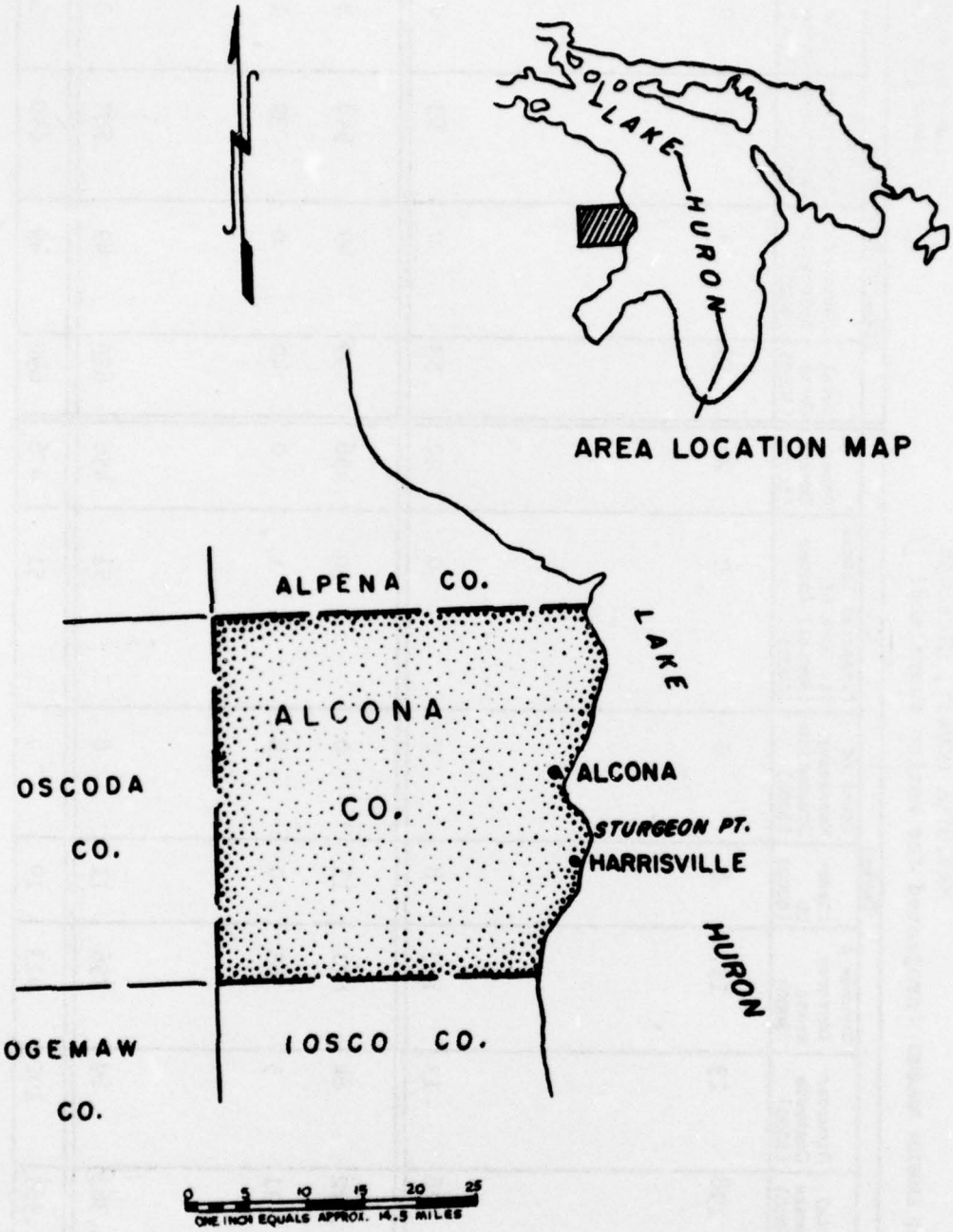
	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	106	7	84	4	0	0	11	26	0	26	0
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total	106	7	84	4	0	0	11	26	0	26	0
Erosion Damages											
Residential	682	45	360	6	0	27	244	293	24	268	1
Commercial/ Industrial	91	5	85	0	0	1	0	40	0	39	1
Transportation											
Agriculture											
Other											
Total	773	50	445	6	0	28	244	333	24	307	2
TOTAL Flood and Erosion	879	57	529	10	0	28	255	359	24	333	2

TABLE 34 : MANISTEE COUNTY, MICHIGAN Labor Day 1973-Labor Day 1974

SUMMARY OF FLOOD AND EROSION DAMAGES (projected for entire shoreland) 1/

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	198	13	157	8	0	0	20	53	0	53	0
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total	198	13	157	8	0	0	20	53	0	53	0
Erosion Damages											
Residential	1,272	84	671	11	0	50	456	599	49	548	2
Commercial/ Industrial	91	5	85	0	0	1	0	40	0	39	1
Transportation											
Agriculture											
Other											
Total	1,363	89	756	11	0	51	456	639	49	587	3
TOTAL Flood and Erosion	1,561	102	913	19	0	51	476	692	49	640	3

1/ Based on 53 percent response.



ALCONA COUNTY, MICHIGAN

Figure 10

particularly evident in the northern portion of the county where 88 percent of the respondents to the self-administered assessment stated that they used their property on a seasonal basis.

The coast along this county consists mainly of resort towns which have a very small year-round resident population. One of the largest of these towns is Harrisville, with a population of 487. Shoreland ownership and use is shown in Table 35.

b. Nature and Extent of Physical Losses

The amount of beach lost reported by property owners was minimal in comparison with other surveyed counties. The least volume of bluff erosion in the Michigan pilot counties was reported in this area. The substantial number of dwellings located near the bluff's edge increases the amount of dollar damages reported due to erosion (see Table 36).

c. Flood and Erosion Damages

Moderate flooding damages were reported in Alcona County, with the greatest loss occurring to grounds and improvements. Substantial damage was reported to miscellaneous items, while damages to structures and contents and costs of clean-up were minimal.

Moderate economic losses due to erosion were reported by property owners in Alcona County. As Tables 37 and 38 depict, grounds and improvements sustained the bulk of the damages, while structural and content loss as well as miscellaneous damages were substantially less. Minimal clean-up costs were incurred. Expenditures for protective measures totalled nearly $100,000, about half of the amount lost to erosion damage. Property owners spent $95,000 on permanent structures alone.

6. Huron County

a. Physical Description

This Lower Peninsula county covers the entire tip of the "thumb" area on Lake Huron. Tuscola County lies to the southwest of Huron County while Sanilac County is to the southeast. The shoreline along Huron County is 92.4 miles in length. Figure 11 is a map of Huron County.

The shoreline in Huron County from the Tuscola-Huron County line up to Sand Point has marshy, shallow water inshore with no noticeable bluff. Sand Point, a long, narrow peninsula, juts westward into Saginaw Bay and forms the northern limit of Wildfowl Bay. From Sand Point to a point between Port Austin and Pointe Aux Barques, the shoreline is composed of sand beaches, with generally shallow water inshore, and a bluff of uneven sand ridges, some of which extend to 25 feet above the water. Near Port Austin there are outcroppings of bedrock at the bluff line. Deep water extends closer

TABLE 35 :
SUMMARY OF GREAT LAKES SHORELINE USE, OWNERSHIP, VALUE & PROBLEM IDENTIFICATION

ALCONA COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

Shoreland Use	Miles Shoreland	Ownership				Aver. Assess. Value/front Foot	Problem Identification						Not subject to Erosion or Flood Damages
							Subject to Erosion			Subject to Flooding			
		Federal	State	Local	Priv.		Permanent Protection	Expedient Protection	Unprotected	Perm. Prot.	Exped. Prot.	Unprotected	
		Miles	Miles	Miles	Miles	$/ft	Miles	Miles	Miles	Miles	Miles	Miles	Miles
Residential Permanent Seasonal													
Commercial/ Industrial													
Transportation													
Utilities													
Agric/Forest & Undeveloped													
Other, Public Park & Open Space													
Total	26.7					215							

TABLE 36:
PHYSICAL EROSION LOSSES

ALCONA COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	Number of Residences Located Within feet of edge of bluff					
			0-25	26-50	51-75	76-100	101-150	151-200
Actual Reported Projection for Entire Co.	6,400	16,200	50	71	32	37	12	9

TABLE 37 :
SUMMARY OF FLOOD AND EROSION DAMAGES (actual reported) ALCONA COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	84	4	61	1	0	1	17	26	1	25	+
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total	84	4	61	1	0	1	17	26	1	25	0
Erosion Damages											
Residential	297	53	195	8	0	2	39	99	2	95	2
Commercial/ Industrial	45	0	45	0	0	0	0	0	0	0	0
Transportation											
Agriculture											
Other											
Total	342	53	240	8	0	2	39	99	2	95	2
TOTAL Flood and Erosion	426	57	301	9	0	3	56	125	3	120	2

+ = positive value reported, less than $1,000.

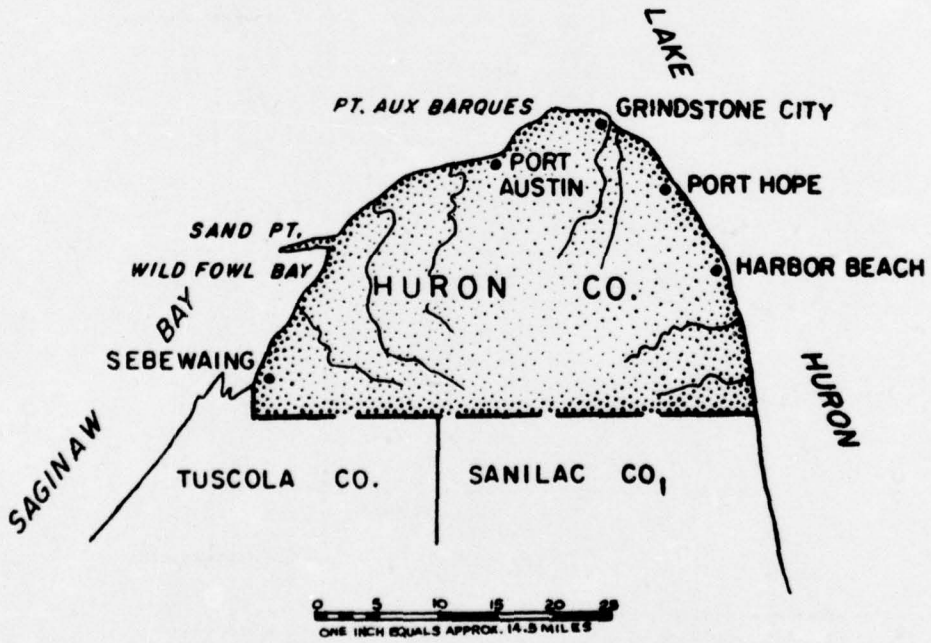
TABLE 38 : ALCONA COUNTY MICHIGAN Labor Day 1972-
SUMMARY OF FLOOD AND EROSION DAMAGES (projected for entire shoreland) 1/ Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	142	7	103	2	0	1	29	42	2	40	+
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total	142	7	103	2	0	1	29	42	2	40	0
Erosion Damages											
Residential	502	90	330	13	0	3	66	160	3	154	3
Commercial/ Industrial	45	0	45	0	0	0	0	0	0	0	0
Transportation											
Agriculture											
Other											
Total	547	90	375	13	0	3	66	160	3	154	3
TOTAL Flood and Erosion	689	97	478	15	0	4	95	202	5	194	3

1/ Based on 62 percent response

+ = positive value reported, less than $1,000.

AREA LOCATION MAP



HURON COUNTY, MICHIGAN

Figure 11

to shore in the vicinity of Port Austin. The lake bed in this area contains several rocky reefs. From Pointe Aux Barques to a point eastward of Grindstone City, the shoreline is sandstone bluff about ten feet above water with some narrow beach existing at the base. Southeastward to Port Hope, the shore and inshore water areas are boulder strewn, and the bluffs become more pronounced and are principally clay. This condition exists to the Huron-Sanilac County line with a few boulders and little sand beach, except in scattered areas.

Ninety-seven percent of lakeshore properties are residential, the majority used seasonally. Harbor Beach and Sebewaing are two of the larger coastal cities in Huron County, with populations of 2,282 and 2,026, respectively. Shoreland ownership and use is shown in Table 39.

b. Nature and Extent of Physical Losses

Nearly one-third of Huron County's shoreline is classified as non-erodible, particularly in areas of marshy lowlands and non-erodible clay bluffs. Because of the shallow offshore water area, little wave action is dissipated directly on the marshy lowlands and against the clay bluffs. However, there are some 12 miles of scattered high risk areas. Although economic losses due to erosion were moderate in this county, the reported amounts of beach and bluff material eroded were quite substantial. Huron County reported the greatest amount of beach material lost of the six Michigan counties examined (15 million square feet), and the volume of bluff material lost was the second largest amount. Structural damages were low because of the limited number of residences located within 50 feet of the bluff. For actual and projected amounts of beach area lost and shoreline erosion, see Table 40.

c. Flood and Erosion Damages

Huron County suffered damages from both flooding and erosion. Grounds and improvements were more heavily damaged than other damage categories. Expenditures for protective structures were almost half of actual damages, as shown in Tables 41 and 42.

D. New York - Oswego County

1. Physical Description

Oswego County, New York, lies at the southeastern end of Lake Ontario. The county's lake shoreline totals about 35.4 miles. In addition, 15.6 miles of North Pond shoreline were included since the level of this water body is directly dependent on the level of Lake Ontario. The county extends from IJC coordinated mileage number 119.3 to 154.7 (see Figure 12).

TABLE 39 :
SUMMARY OF GREAT LAKES SHORELINE USE, OWNERSHIP, VALUE & PROBLEM IDENTIFICATION

HURON COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

Shoreland Use	Miles Shore-land	Ownership				Aver. Assess. Value/front Foot	Problem Identification						Not subject to Erosion or Flood Damages
							Subject to Erosion			Subject to Flooding			
		Federal	State	Local	Priv.		Permanent Protection	Expedient Protection	Unpro-tected	Perm. Prot.	Exped. Prot.	Unpro-tected	
		Miles	Miles	Miles	Miles	$/ft	Miles	Miles	Miles	Miles	Miles	Miles	Miles
Residential Permanent Seasonal													
Commercial/ Industrial													
Transportation													
Utilities													
Agric/Forest & Undeveloped													
Other, Public Park & Open Space													
Total	92.4					227							

TABLE 40:
PHYSICAL EROSION LOSSES

HURON COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	Number of Residences Located Within feet of edge of bluff					
			0-25	26-50	51-75	76-100	101-150	151-200
Actual Reported	15,000	202,800						
Projection for Entire Co.	17,100	231,000	26	60	28	17	12	6

TABLE 41 :
SUMMARY OF FLOOD AND EROSION DAMAGES (actual reported) HURON COUNTY, MICHIGAN

Labor Day 1972-
Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	128	4	75	15	0	1	33	26	0	26	+
Commercial/ Industrial											
Transportation											
Utilities											
Agriculture											
Other											
Total	128	4	75	15	0	1	33	26	0	26	0
Erosion Damages											
Residential	278	21	189	13	0	5	50	210	+	208	2
Commercial/ Industrial	48	1	27	0	0	20	0	0	0	0	0
Transportation											
Agriculture											
Other											
Total	326	22	216	13	0	25	50	210	0	208	2
TOTAL Flood and Erosion	454	26	291	28	0	26	83	236	0	234	2

+ = positive value reported, less than $1,000.

HURON COUNTY, MICHIGAN

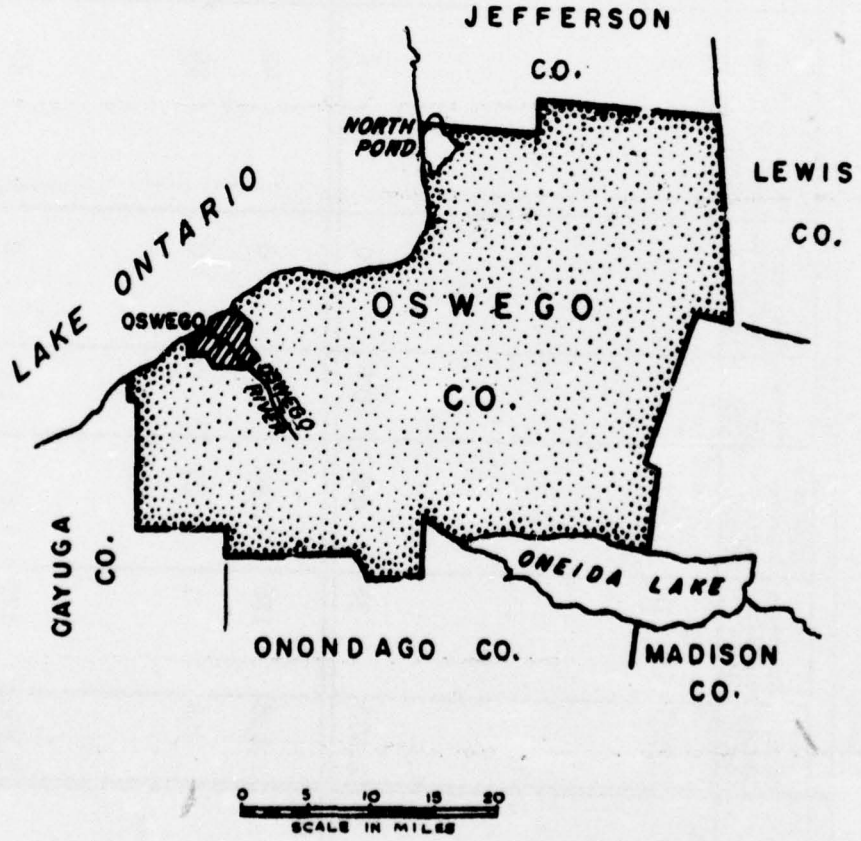
OF FLOOD AND EROSION DAMAGES (projected for entire shoreland) 1/

Labor Day 1972-
Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
mages											
ial	1,078	34	632	126	0	8	278	227	0	227	+
al/ al											
rtation											
s											
ture											
	1,078	34	632	126	0	8	278	227	0	227	0
Damages											
tial	2,338	176	1,590	109	0	42	421	1,833	+	1,815	18
ial/ ial	48	1	27	0	0	20	0	0	0	0	0
rtation											
ture											
	2,386	177	1,617	109	0	62	421	1,833	0	1,815	18
lood sion	3,464	211	2,249	235	0	70	699	2,060	0	2,042	18

sed on 12 percent of all residential properties.
ositive value reported, less than $1,000.

AREA LOCATION MAP



OSWEGO COUNTY, NEW YORK

Figure 12

The Oswego County shoreline is generally exposed to direct wave attack from the water of Lake Ontario in that it is lacking in embayed areas. The North Pond embayment is the only significant exception. Starting in the north end of the county and proceeding south the shoreforms change from (1) primarily erodible low plains to, (2) low bluffs erodible (primarily of sandy material) to, (3) high bluffs non-erodible. These high bluffs are comprised of till overlying bedrock. In most areas the bedrock is of sufficient height or width to protect the toe of the till bluff.

Use and ownership of the shoreline are generally the same throughout the entire county. Private seasonal residences are the primary developments found along the shoreline. In addition, there are several small marinas and hotels. The City of Oswego is the only significant community directly on the lake. The majority of the non-residential, non-private properties are concentrated in or near the city. (See Table 43.)

2. Physical losses due to erosion and covering of beaches by high water are shown in Table 44.

3. Flood and Erosion Damages

In general the shoreline flooding and erosion problems decrease moving from the northern to the southern portion of the shoreline. This is due primarily to land form differences. Since the majority of the lake shoreline is exposed to the open lake, there have been a large number (468) of expedient shore protective devices constructed. Only one significant permanent device is in place. This is a structure constructed by the Corps of Engineers located near the mouth of the Oswego River protecting Oswego Harbor. (See Tables 45 and 46.)

TABLE 43 :
SUMMARY OF GREAT LAKES SHORELINE USE, OWNERSHIP, VALUE & PROBLEM IDENTIFICATION

OSWEGO COUNTY, NEW YORK

Labor Day 1972-
Labor Day 1974

Shoreland Use	Miles Shore-land	Ownership				Aver. Assess. Value/front Foot	Problem Identification						Not subject to Erosion or Flood Damages
							Subject to Erosion			Subject to Flooding			
		Federal	State	Local	Priv.		Permanent Protection	Expedient Protection	Unprotected	Perm. Prot.	Exped. Prot.	Unprotected	
		Miles	Miles	Miles	Miles	$/ft	Miles	Miles	Miles	Miles	Miles	Miles	Miles
Residential Permanent	.43				.43			.30	.13				0
Seasonal	19.45				19.45			8.55	10.65				.25
Commercial/ Industrial	8.08	.05	2.78	.29	4.96		1.74	1.77	3.74				.83
Transportation													
Utilities													
Agric/Forest & Undeveloped	19.06			.14	18.92			1.77	17.14				.75
Other, Public Park & Open Space	2.91		.63	.12	2.16			1.09	1.81				.01
Total	49.93	.05	3.41	.55	45.92		1.74	12.88	33.47				1.84

TABLE 44 :
PHYSICAL EROSION LOSSES

OSWEGO COUNTY, NEW YORK

Labor Day 1972-
Labor Day 1974

	Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	Number of Residences Located Within feet of edge of bluff					
			0-25 1/	26-50	51-75	76-100	101-150	151-200
Actual Reported Projection for Entire Co.	1,785	15,485	123	123	46	18	13	14

1/ Two residences destroyed.

TABLE 45 :
SUMMARY OF FLOOD AND EROSION DAMAGES (actual reported) OSWEGO COUNTY, NEW YORK

Labor Day 1972-
Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	1/ Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	882	119	495	0	0	10	258	236	0	103	133
Commercial/ Industrial	25	1	2	6	+	16	0	10	0	10	0
Transportation											
Utilities											
Agriculture											
Other	1	0	+	+	0	0	0	0	0	0	0
Total	907	120	497	6	0	26	258	246	0	113	133
Erosion Damages											
Residential	1,148	68	757	0	0	3	320	792	0	392	400
Commercial/ Industrial	528	117	371	0	5	35	0	27	10	16	1
Transportation											
Agriculture											
Other	893	166	678	49	0	0	0	10	0	10	0
Total	2,569	351	1,806	49	5	38	320	829	10	418	401
TOTAL Flood and Erosion	3,476	471	2,303	55	5	64	578	1,075	10	531	534

1/ For residential properties damages to protective structures and clean-up costs are included in "Other Damages".

+ = positive value reported, less than $1,000.

TABLE 46 :
SUMMARY OF FLOOD AND EROSION DAMAGES (projected for entire shoreland) 1/

OSWEGO COUNTY, NEW YORK

Labor Day 1972-
Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	1,265	171	710	0	0	14	370	339	0	148	191
Commercial/ Industrial	25	1	2	6	+	16	0	10	0	10	0
Transportation											
Utilities											
Agriculture											
Other	+	0	+	+	0	0	0	0	0	0	0
Total	1,290	172	712	6	0	30	370	349	0	158	191
Erosion Damages											
Residential	1,647	98	1,086	0	0	4	459	1,136	0	562	574
Commercial/ Industrial	528	117	371	0	5	35	0	27	10	16	1
Transportation											
Agriculture											
Other	893	166	678	49	0	0	0	10	0	10	0
Total	3,068	381	2,135	49	5	39	459	1,173	10	588	575
TOTAL Flood and Erosion	4,358	553	2,847	55	5	69	829	1,522	10	746	766

1/ Based on 69.7 percent sample.

+ = positive value reported, less than $1,000.

2/ Clean-up and damage to protective structures included in "Other Damages."

SECTION XI

SUMMARY OF PILOT PROGRAM RESULTS

A. Total Damages in 11 Pilot Counties

The total amounts of beach lost and bluff erosion in the 11 counties are shown in Table 47. Total reported and projected flooding and erosion damages are shown in Tables 48 and 49. The pilot program damage data are summarized by lake and state in Tables 50 to 53. Because of constraints in funds and time, it was not possible to determine annual damages which provide the only acceptable basis for the evaulation of regulation plans; however, such work is scheduled to be completed by October 1976. Furthermore, it appears that much of the damage data reported are self-supplied estimates obtained from a portion of the particular total county shoreline involved. Consequently it is not possible to use the damage data with extreme reliability since there was no consistent evaluation of damage extent and degree by trained personnel who have experience in making such damage assessments. This is not to say that the data are of no value or that the results should not be presented but only to point out the obvious fact that such information must be qualified as to its use and reliability in making further assumptions or evaluations of shoreline damages as related to regulatory actions.

B. Study Methods--Lessons Learned

The original objectives of the shoreline damage study program as viewed by some state participants, were unable to be met as a result of inadequate funds, time constraints, and the absense of a comprehensive working task force to investigate the various shoreline effects, and prepare a detailed technical report on bluff losses, bluff erosion, storm wave data and accurate quantified damage data. With these considerations, in recognition that some information is better than none, and to provide a beginning effort to derive the needed facts, it was decided to evaluate the 11 county pilot study program.

Based on the data collected in the pilot studies, the scope of work for contracts to be let for the remaining counties was revieved. The goal was to achieve savings in the costs and time required per county for future studies. Items of work which produced duplicative information or information which was not directly applicable to the evaluation of lake level regulation plans as directed by the study authorization (reprinted in Section 1) were eliminated. In addition, ways were found to streamline other procedures. Specific modifications to the scope of work are as follows:

1. The collection of soil samples and bluff profiles was deleted from future studies. The data collected, while useful for other purposes, were not applicable to the estimation of damages incurred and therefore are outside of the study authority. The laboratory soil testing was accomplished by EPA as part of its involvement in the Pollution from Land Use Activities Reference Group (PLUARG), organized under the supervision of the International Joint Commission. The results of the soils analysis will be published in a report of the IJC - PLUARG Task D Group.

2. There are no universally accepted formulas for computing beach area lost and bluff volume eroded. The study partners agreed that the parameter estimates in this report are subject to revision when agreement is reached on modified formulas with which to calculate these quantities.

3. The identification of high water marks was eliminated because the period of time from storm event to field survey was in most cases too long. High water marks could be located with confidence in relatively few areas.

4. In the pilot study, follow-up interviews were held with some respondents of the residential self-administered damage assessment. The purpose was to discover the existence of bias. The data thus collected were inconclusive from the standpoint of statistical tests of significance. It was determined that additional interviews

of respondents were not of sufficient value to be retained in further surveys.

5. Field inventory of protective structures. This item of work was viewed by some of the states as producing valuable information for their Coastal Zone Management programs as well as existing regulatory functions. However, the mailed assessment produced information about the costs of protective structures built during the study period, plus the damages to existing protective structures. The field inventory was determined to be duplicative and has been deleted from the scope of work.

6. The pilot studies included field surveys of shore forms and shore types. These field observations were recorded in narrative form and presented in tables in the county reports. This item was somewhat duplicative of information contained in the National Shoreline Study: Great Lakes Regional Inventory, Corps of Engineers, North Central Division, 1971. The data produced were not directly applicable to the estimation of damages, and the item of work was therefore deleted.

7. Narrative descriptions of shoreline ownership and damaged areas were also a part of the pilot study reports. Shoreline ownership data is also found in the Great Lakes Regional Inventory report, above. The narrative descriptions of damaged areas involved large costs to both the contractors for writing these sections and the Corps of Engineers for reviewing and editing the manuscripts. The information provided incremental to the dollar damage figures did not justify the incremental costs. Therefore, the narrative portions have been deleted from future studies.

8. The pilot studies also required assessments of the recreational, aesthetic, and environmental effects of high water levels. The states had mixed reactions to the results of these studies. Currently, the State of Michigan is investigating means of acquiring data to represent the above impacts.

9. Aerial photo mosaics were completed for the shorelines of all pilot study counties. These panels did not directly apply to the authorized study purpose. In addition, some of the information provided was duplicative of the Great Lakes Regional Inventory, above, or repeated data presented elsewhere in the pilot study report. Accordingly, this item of work has been dropped from future studies.

10. The pilot study data collection methods aimed at complete census coverage of the riparian owners. As a result of the Huron County sampling approach study and Appendix V, Shoreline Damage Study: An Appraisal with Recommendations, it has been determined that a 20 percent sample coverage for each county would provide results, when

projected for the total county, having an adequate confidence factor. However, a decision to use a 20 percent random sample in lieu of census is a subject for further discussion with the involved states.

11. The factual evaluation of damages and of the effectiveness of protective measures employed to reduce damages must be made by technically skilled persons with experience in making such evaluations. Since such efforts cannot be provided under present study constraints, the resultant data from surveys of these factors must not be used as firm reliable data.

TABLE 47:
PHYSICAL EROSION LOSSES 11 PILOT COUNTIES
Projection for Entire Shoreline

Labor Day 1972-
Labor Day 1974

Lake	Physical Losses: Amount of Beach Area Lost (000 sq. ft.)	Amount of Bluff Volume Lost (000 cu. ft.)	Number of Residences Located Within ___ Feet of Edge Of Bluff: 0-25	26-50	51-75	76-100	101-150	151-200
Superior								
St. Louis Co, MN	463	16,140	27	26	18	16	6	15
Douglas Co, WI 1/	5,781	114,622						
Chippewa Co, MI	9,600	49,100	99	122	47	29	14	10
Michigan								
Schoolcraft Co, MI	14,100	10,600	4	4	6	7	2	2
Brown Co, WI	1,506	32,030	14	6	6	1	3	6
Racine Co, WI	2,250	53,500	12	25	17	14	12	1
Muskegon Co, MI	13,700	224,510	51	54	31	20	12	9
Manistee Co, MI	7,300	99,600	37	44	15	8	7	0
Huron								
Alcona Co, MI	6,400	16,200	50	71	32	37	12	9
Huron Co, MI	17,100	231,000	26	60	28	17	12	6
Ontario								
Oswego Co, NY	1,785	15,485	123	123	46	18	13	14
TOTALS	79,985	862,787	443	535	246	167	93	72

1/ No location data for Douglas County, Wisconsin

TABLE 48 :
SUMMARY OF FLOOD AND EROSION DAMAGES (actual reported) ELEVEN PILOT COUNTIES

Labor Day 1972-
Labor Day 1974

	Damage							Costs of Protection			
	Total 1/ Damage ($000)	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	4,784	230	995	38	0	26	522	380	5	240	135
Commercial/ Industrial	1,472	284	10	43	20	52	8	59	2	42	15
Transportation											
Utilities	334	294	0	40	0	0	0	10	0	10	0
Agriculture											
Other	160	0	+	+	0	0	0	0	0	0	0
Total	6,750	808	1,005	121	20	78	530	449	7	292	150
Erosion Damages											
Residential	7,361	1,066	4,188	254	+	105	1,748	3,259	85	2,751	423
Commercial/ Industrial	1,705	355	1,222	28	5	94	1	1,777	1,418	319	40
Transportation	10	0	10	0	0	0	0	0	0	0	0
Utilities	261	188	13	11	0	0	49	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0
Other	969	183	722	64	0	0	0	2,450	6	2,444	0
Total	10,306	1,792	6,155	357	5	199	1,798	7,486	1,509	5,514	463
TOTAL Flood and Erosion	17,056	2,600	7,160	478	25	277	2,328	7,935	1,516	5,806	613

1/ Totals include Brown County flood damages not presented by category, therefore damage totals do not equal sum of damage catetory values. + = positive value reported, less than $1,000.

TABLE 49 : ELEVEN PILOT COUNTIES Labor Day 1972-
SUMMARY OF FLOOD AND EROSION DAMAGES (projected for entire shoreland) Labor Day 1974

	Damage							Costs of Protection			
	Total Damage ($000) 1/	Structure Contents ($000)	Grounds & Improvements ($000)	Clean-Up ($000)	Costs of Emergency Evacuation ($000)	Financial Losses Net Loss of (Rental) Income ($000)	Other Damage ($000)	Total Costs ($000)	Costs of Relocation ($000)	Costs of Protective Structures ($000)	Other Costs ($000)
Flood Damages											
Residential	6,647	381	2,049	165	0	45	1,034	773	8	571	194
Commercial/ Industrial	1,472	284	10	43	20	52	8	59	2	42	15
Transportation											
Utilities	334	294	0	40	0	0	0	10	0	10	0
Agriculture											
Other	160	0	+	+	0	0	0	0	0	0	0
Total	8,613	959	2,059	248	20	97	1,042	842	10	623	209
Erosion Damages											
Residential	14,007	1,870	8,190	519	0	212	3,216	7,371	209	6,524	638
Commercial/ Industrial	1,705	355	1,222	28	5	94	1	1,771	1,418	319	40
Transportation	10	0	10	0	0	0	0	0	0	0	0
Utilities	261	188	13	11	0	0	49	0	0	0	0
Agriculture	0	0	0	0	0	0	0	0	0	0	0
Other	969	183	722	64	0	0	0	2,450	6	2,444	0
Total	16,952	2,596	10,157	622	5	306	3,266	11,598	1,633	9,287	678
TOTAL Flood and Erosion	25,565	3,555	12,216	870	25	403	4,308	12,440	1,643	9,910	887

1/ Totals include Brown County flood damages not presented by category, therefore damage totals do not equal sum of damage category values. + = positive value reported, less than $1,000.

TABLE 50

SUMMARY OF FLOOD AND EROSION DAMAGE - ACTUAL REPORTED
(EXCLUDING EXPENDITURES FOR PROTECTION MEASURES)
LABOR DAY 1972-LABOR DAY 1974

	Lake Superior ($000)	Lake Michigan ($000)	Lake Huron ($000)	Lake Ontario ($000)	Total ($000)
Minnesota					
St. Louis Co.	1,173				1,173
Wisconsin					8,153
Douglas Co.	170				
Brown Co.		6,323			
Racine Co.		1,660			
Michigan					4,254
Chippewa Co.	1,115				
Schoolcraft Co.		41			
Muskegon Co.		1,339			
Manistee Co.		879			
Alcona Co.			426		
Huron Co.			454		
New York					
Oswego Co.				3,476	3,476
Totals	2,458	10,242	880	3,476	17,056

TABLE 51

SUMMARY OF FLOOD AND EROSION DAMAGE -
PROJECTED FOR ENTIRE SHORELINE
(EXCLUDING EXPENDITURES FOR PROTECTION MEASURES)
LABOR DAY 1972-LABOR DAY 1974

	Lake Superior ($000)	Lake Michigan ($000)	Lake Huron ($000)	Lake Ontario ($000)	Total ($000)
Minnesota					
St. Louis Co.	1,370				1,370
Wisconsin					9,971
Douglas Co.	252				
Brown Co.		7,139			
Racine Co.		2,580			
Michigan					9,866
Chippewa Co.	1,766				
Schoolcraft Co.		115			
Muskegon Co.		2,271			
Manistee Co.		1,561			
Alcona Co.			689		
Huron Co.			3,464		
New York					
Oswego Co.				4,358	4,358
Totals	3,388	13,666	4,153	4,358	25,565

TABLE 52

SUMMARY OF FLOOD AND EROSION DAMAGES - ACTUAL REPORTED
(INCLUDING EXPENDITURES FOR PROTECTION MEASURES)
LABOR DAY 1972-LABOR DAY 1974

	Lake Superior ($000)	Lake Michigan ($000)	Lake Huron ($000)	Lake Ontario ($000)	Total ($000)
Minnesota					
St. Louis Co.	1,433				1,433
Wisconsin					13,034
Douglas Co.	1,601				
Brown Co.		7,865			
Racine Co.		3,568			
Michigan					5,973
Chippewa Co.	1,620				
Schoolcraft Co.		45			
Muskegon Co.		1,829			
Manistee Co.		1,238			
Alcona Co.			551		
Huron Co.			690		
New York					
Oswego Co.				4,551	4,551
Totals	4,654	14,545	1,241	4,551	24,991

TABLE 53

SUMMARY OF FLOOD AND EROSION DAMAGE -
PROJECTED FOR ENTIRE SHORELINE
(INCLUDING EXPENDITURES FOR PROTECTION MEASURES)
LABOR DAY 1972-LABOR DAY 1974

	Lake Superior ($000)	Lake Michigan ($000)	Lake Huron ($000)	Lake Ontario ($000)	Total ($000)
Minnesota					
St. Louis Co.	1,683				1,683
Wisconsin					15,428
Douglas Co.	1,689				
Brown Co.		9,001			
Racine Co.		4,738			
Michigan					15,014
Chippewa Co.	2,586				
Schoolcraft Co.		135			
Muskegon Co.		3,625			
Manistee Co.		2,253			
Alcona Co.			891		
Huron Co.			5,524		
New York					
Oswego Co.				5,880	5,880
Totals	5,958	19,752	6,415	5,880	38,005

SECTION XII

ESTIMATION OF DAMAGES FOR TOTAL U.S. GREAT LAKES SHORELAND

At the inception of the pilot program it was hoped that the findings in the pilot counties could be extrapolated to cover the entire U.S. Great Lakes shoreland. The survey results cannot be so extrapolated with statistical certainty at this time. Additional studies are necessary to determine the degree to which accurate quantitative judgments about the remaining 71 counties can be made on the basis of these 11 pilot counties. However, it might be useful to compare the pilot study results with the findings of the 1952 damage survey. Until such time as budget constraints allow the computation of average annual damages based on storm event and hydrologic data, it must be noted that we are comparing damage periods rather than annual damages. Although annual damages provide the only acceptable basis for the evaluation of regulation plans, the property owner may well be more interested in the amounts of total damages experienced over the entire periods of high water. After adjusting for price levels it would seem that any major differences in the amounts of damages recorded would be attributable to growth and development which has occurred since 1952, geological changes with regard to exposed shoreline, and differences in storm activity.

Table 54 lists damages recorded in the 1952 survey and adjusted using the Engineering News Record Building Cost Index by a factor of 2.76 to September 1973 price levels. The damage data in the pilot program apply to a two-year period; it is assumed that using midpoint price level of September 1973 best represents that period. Damage data collected in the 1952 survey were not reported on a county basis. Therefore, reaches from the 1952 study were selected to approximate county boundaries as closely as the data allowed. Also presented is a direct comparison of the 1952 survey and pilot program damage data. Expenditures for protective measures have been included in the pilot program totals because these costs were classified as damage in the 1952 survey.

The estimate of total damage to all shore properties during the 1951-52 period was $61 million. That damage updated to September 1973 price levels would be about $168 million. The 1975 pilot program found that the current damages exceeded the early period by a factor of 2.6. Using that factor, the estimated shoreland damages for the total U.S. shoreline would be in the order of $430 million. However, on a reach basis, the spread of comparable data as shown in Table 54 is too great to place any reliance on this method for damage projection. Since the degree of reliability and accuracy of the data from the present study cannot be determined at this time, the comparisons herein and in Table 54 merely represent an exercise in statistical evaluation and the results and conclusions from the data cannot be used as positive indices of the comparative damage extent.

TABLE 54:
COMPARISON OF PILOT PROGRAM 1/ AND 1951-1952 DAMAGE DATA (UPDATED TO SEPTEMBER 1973 PRICE LEVELS)

Pilot Program County	Lake	1951-1952 Survey Study Reach	Flood Damages ($000) 1952 Study 1951-52 Prices	Flood Damages ($000) 1952 Study Sep 1973 Prices	Flood Damages ($000) Pilot Program	Erosion Damages ($000) 1952 Study 1951-52 Prices	Erosion Damages ($000) 1952 Study Sep 1973 Prices	Erosion Damages ($000) Pilot Program	Total ($000) 1952 Study 1951-52 Prices	Total ($000) 1952 Study Sep 1973 Prices	Total ($000) Pilot Program	Ratio of Pilot Program/ 1952 Study
St. Louis Co. MN	Sup	Two Harbors to Dul-Sup Hbr	$1,119	$3,088	$1,108	$ 532	$1,468	$ 575	$1,651	$ 4,556	$ 1,683	0.4
Douglas Co. WI	Sup	Dul-Sup Hbr to Port Wing	200	552	0	235	649	1,689	435	1,201	1,689	1.4
Chippewa Co. MI	Sup	Whitefish Pt to Sault Ste. Marie	0	0	500	361	996	2,086	361	996	2,586	2.6
Schoolcraft Co. MI	Mich	Straits of Mack. to Manistique	8	22	13	340	938	122	348	960	135	0.1
Brown Co. WI	Mich	Mich-Wis State-line to Green Bay	535	1,476	4,188	168	464	4,813	703	1,940	9,001	4.6
Racine Co. WI	Mich	Milwaukee to Racine	0	0	0	314	867	4,738	314	867	4,738	5.5
Muskegon Co. MI	Mich	Grand Haven to Muskegon	44	121	267	421	1,162	3,358	465	1,283	3,625	2.8
Manistee Co. MI	Mich	Manistee to Frankfort	198	546	251	151	417	2,002	349	963	2,253	2.3
Alcona Co. MI	Mich	1/7 of Sts. of Mack to Bay City	33	91	184	148	408	707	181	499	891	1.8
Huron Co. MI	Hur	1/2 of Pt Austin to Port Huron	0	0	1,305	225	621	4,219	225	621	5,524	8.9
Oswego Co. NY	Ont	Great Sodus Bay to Oswego, NY	85	235	1,639	195	538	4,241	280	773	5,880	7.6
TOTALS			$2,222	$6,131	$9,455	$3,090	$8,528	$28,550	$5,312	$14,659	$38,005	2.6

1/ Projected for entire county shoreline, including expenditures for protective works.

SECTION XIII

CONCLUSIONS

Total damages resulting from the 1972-1974 high water period seem to be in the magnitude of two to three times greater (after adjusting for price level changes and development) than damages for the 1951-1952 period for the 11 counties studied. The increase in damages varied considerably among the counties. St. Louis County, Minnesota, and Schoolcraft County, Michigan, seem to have suffered greater damages during the earlier period. Further study is needed to determine whether damages on an average annual basis have increased in that magnitude over the entire Great Lakes shoreline.

The most significant conclusion that can be made is that it is not possible to make a comprehensive factual survey and evaluation of shoreline processes, effects, and damages without adequate funds, technical staff and a suitable time framework for conduct of the study.

SECTION XIV

RECOMMENDATIONS

It is recommended that:

- The study of shoreland damages, resulting from the high water period beginning in 1972, be extended to the remaining 72 counties bordering the U.S. shoreline.

- The study of the remaining counties be completed as quickly as possible to avoid loss of information and to assure the reliability of the data collected.

- It is recommended that the affected states and the involved Federal agencies cooperate in better fulfilling the objectives of the pilot study, including an evaluation of bluff losses, bluff erosion, shoreline flooding and erosion damage costs, viability of protective works and effects of storm waves, as related to regulatory effects and natural climatic factors, by establishing a coordinated Federal-state program to meet these objectives.

STATEMENT OF THE PARTICIPATING STATE MEMBERS OF THE
FEDERAL REGIONAL COUNCIL/GREAT LAKES BASIN COMMISSION
JOINT TASK FORCE ON REDUCTION OF SHORELAND DAMAGES

The Great Lakes Shoreland Damage Study has been a partnership effort among the Corps of Engineers and the States of Michigan, Minnesota, New York, and Wisconsin. In our capacities as members of the Joint Task Force we accept the results of this pilot study as summarized in Section XI, and we concur in the study recommendations as stated in Section XIV.

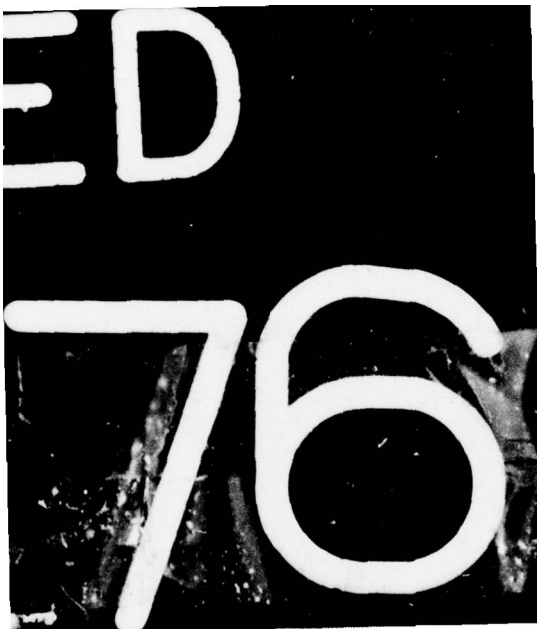
William D. Marks - Michigan

Gene Hollenstein - Minnesota

William H. Lee - New York

Ted Lauf - Wisconsin

Enclosure 1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